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CONTENTS

Page

1. Geologic Maps, Areal and Regional Geology (including Guidebooks) 1
2. Geomorphology 5
3. Structural Geology 7
4. Stratigraphy and Historical Geology 10
5. Paleontology 13
6. Geophysics 15
7. Geochemistry 25
8. Mineralogy and Crystallography 33
9. Igneous and Metamorphic Petrology 35
10. Sedimentary Petrology 38
11. Geohydrology 40
12. Mineral Deposits (including Geochemical Prospecting) 44
13. Fuels 47
14. Engineering Geology 50
15. Miscellaneous 55

SERIALS

The following list gives in full the abbreviated citations used after the titles of papers in this issue of GeoScience Abstracts.

Akademiya Nauk SSSR, Bulletin [Izvestiya], Geophysics Series, in English translation (American Geophysical Union). New York.
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New Jersey, Dept. of Conservation and Economic Development, Division of Water Policy and Supply, Water Resources Circular. Trenton, New Jersey.
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Puerto Rico, Division of Mineralogy and Geology, Bulletin. Hato Rey, Puerto Rico.
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U. S. Atomic Energy Commission, [Publication]. Oak Ridge, Tennessee.
U. S. Geological Survey, Bulletin; Geologic Quadrangle Map; Mineral Investigations Map; Miscellaneous Investigations Map; Professional Paper; Trace Elements Memorandum Report; Water-Supply Paper. Washington, D. C.
Utah Geological and Mineralogical Survey, Bulletin. Salt Lake City, Utah.
Wisconsin, University, Dept. of Meteorology, Report to the Lakes and Streams Investigations Committee. Madison, Wisconsin.

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GeoScience Abstracts

1. GEOLOGIC MAPS, AREAL AND REGIONAL GEOLOGY

PART 1. GEOLOGIC MAPS

See also: Mineral Deposits 1-3152.

1-2933. Cass, J.T. RECONNAISSANCE GEOLOGIC MAP OF THE UNALAKLEET QUADRANGLE, ALASKA: U.S. Geol. Survey, Misc. Inv. Map I-288, scale 1:250,000, contour intervals 200 and 1,000 ft., lat. 63°-64°N., long. 159°-162°W., 1959.

This map covers part of the Koyukuk Cretaceous basin in W.-central Alaska. The map shows thick sequences of both sedimentary and igneous rocks, most of which are Cretaceous and Tertiary in age, as well as the prominent faults and the axes of the many folds in the area. Data used in compiling the map were derived largely from aerial photographs, supplemented by data from the out-of-print report of a ground study in the area. --U. S. Geol. Survey.

1-2934. Anderson, Charles A. PRELIMINARY GEOLOGIC MAP OF THE NW 1/4 MAYER QUADRANGLE, YAVAPAI COUNTY, ARIZONA: U.S. Geol. Survey, Mineral Inv. Map MF-228, scale 1:24,000, contour interval 50 ft., lat. 34°22'30"-34°30'N., long. 112°07'30"-112°15'W., 1959.

1-2935. Burbank, W.S., T.S. Lovering, Edwin N. Goddard, and Edwin B. Eckel, comps. GEOLOGIC MAP OF THE STATE OF COLORADO: U.S. Geol. Survey, scale approx. 1 in. to 8 mi., 1935, reprinted 1959.

1-2936. Castle, R.O. SURFICIAL GEOLOGY OF THE WILMINGTON QUADRANGLE, MASSACHUSETTS: U.S. Geol. Survey, Geol. Quad. Map GQ-122, scale 1:31,680, contour interval 10 ft., lat. 42°30'-42°37'30"N., long. 71°07'30"-71°15'W., 1959.

The Wilmington quadrangle is in northeastern Massachusetts. The surficial deposits, which overlie metamorphic rocks of Paleozoic and possible Precambrian age, include till, glacial stream and lake deposits, and Recent deposits of alluvium and peat. Several sequences of outwash are distinguished. The outwash deposits are an important source of aggregate. --U. S. Geol. Survey.

1-2937. Postel, A. Williams, Arthur E. Nelson, and D.R. Wiesnet. GEOLOGY OF THE NICHOLVILLE QUADRANGLE, NEW YORK: U.S. Geol. Survey, Geol. Quad. Map GQ-123, scale 1:62,500, contour interval 20 ft., plat. 44°30'-44°45'N., long. 74°30'-74°45'W., 1959.

The Nicholville quadrangle, in St. Lawrence and Franklin counties, is underlain by a complex of Precambrian rocks and late Cambrian sediments. The area is veneered by Pleistocene till, kame deposits, and outwash sands. The Precambrian rocks and the Late Cambrian rocks are described in detail. The planar and linear structures in the granite in the southern part of the quadrangle define some large folds. --U. S. Geol. Survey.

1-2938. Bramkamp, R.A., and Leon F. Ramirez. GEOGRAPHIC MAP OF THE WADI AL BATIN QUADRANGLE, KINGDOM OF SAUDI ARABIA: U.S. Geol. Survey, Misc. Inv. Map I-203 B, scale 1:500,000, 1959.

PART 2. AREAL AND REGIONAL GEOLOGY

See also: Geohydrology 1-3135, 1-3138; Mineral Deposits 1-3148; Fuels 1-3167.

1-2939. RESUME OF FIELD TRIPS. NINTH ANNUAL FIELD CONFERENCE, SEPTEMBER 9-12, 1959; Alberta Soc. Petroleum Geologists, Jour., v. 7, no. 10, p. 238-243, illus., map, diag., 2 tables, Oct. 1959.

An account of each of the following field trips is given, with notes on geology, by the chairman of the trip. Summaries will permit interested persons to take the same trips with the aid of the road logs published in the 1959 guidebook and these accounts.

Chamney, T. P. Drumheller Field Trip, p. 238-243.
Bossort, D. O. Moose Mountain Field Trip, p. 243.

1-2940. Holland, Stuart S., and others. SYMPOSIUM ON THE ROCKY MOUNTAIN TRENCH: Can. Mining & Metall. Bull., v. 52, no. 565, p. 318-338, 2 illus., 10 maps, May 1959, 19 refs.

The Rocky Mountain Trench is a remarkably continuous topographic feature. The line followed by the trench undoubtedly has structural significance, but it is important to determine to what extent the trench is an erosional form or a structural one. The presence of Tertiary sedimentary rocks at various places in the trench bottom requires explanation; either they have been deposited in the trench or faulted down into position when the trench was formed. Age of formation of the trench as a topographic feature should be related to the Cretaceous erosion surface of the region to the W., as well as to the early Tertiary erosion surface which extended from the Interior Plateaus eastward across the site of the Rocky Mountains. Lack of detailed geological studies leaves the way open for diverse regional geological interpretations. --From introd. by S. S. Holland.

Six papers follow, discussing various aspects of the trench. They are separately abstracted below, in the order in which they appear in the symposium.

1-2941. Armstrong, J.E. PHYSIOGRAPHY OF THE ROCKY MOUNTAIN TRENCH (In: Holland, Stuart S., and others. Symposium on the Rocky Mountain Trench: Can. Mining & Metall. Bull., v. 52, no. 565, p. 318-321, map, May 1959) 9 refs.

The Rocky Mountain Trench is in the main a great, nearly flat-bottomed, parallel-sided trough several thousand feet deep and averaging from 2 to 10 mi. wide. It extends from Flathead Lake, Montana, northwestward to the Grand Canyon of the Fraser River, where it merges into the Nechako plateau. Discontinuous extensions carry it further to Chee House on the Kechika River. The northern and southern sections of the trench, the Nechako plateau, and Tintina Valley are briefly described.

Numerous parallel or associated lineaments are probably structurally related to the trench. --M. Russell.

1-2942. Henderson, G.G.L. A SUMMARY OF THE REGIONAL STRUCTURE AND STRATIGRAPHY OF THE ROCKY MOUNTAIN TRENCH (In: Holland, Stuart S., and others. Symposium on the Rocky Moun-

tain Trench: Can. Mining & Metall. Bull., v. 52, no. 565, p. 322-327, 4 maps, May 1959) 5 refs.

The Rocky Mountain Trench is in an area which in late Paleozoic and Mesozoic time marked the transition from a rapidly subsiding Cordilleran geosyncline on the W. and a stable shelf to the E. From Jurassic to mid-Cretaceous the geosyncline was destroyed by the Nevadian orogeny.

Different structural relationships exist at different places; in some areas the dominant structure is thrust faulting, in others it is normal, and in still others strike-slip faulting is indicated.

The gross shape and regional structural relationships are controlled by the zone of faulting. It is suggested that the basement structure underlying the trench may be the eastern hingeline of the Cordilleran geosyncline. --M. Russell.

1-2943. Leech, G.B. THE SOUTHERN PART OF THE ROCKY MOUNTAIN TRENCH (In: Holland, Stuart S., and others. Symposium on the Rocky Mountain Trench: Can. Mining & Metall. Bull., v. 52, no. 565, p. 327-333, 2 illus., 5 maps, May 1959) 5 refs.

The southern part of the Rocky Mountain Trench differs physiographically and geologically from much of the rest of it. The chief physiographic differences are that it is relatively sinuous and that its cross section is asymmetrical, the E. wall being distinct and abrupt and the W. side commonly irregular and topographically more subdued. The chief geological differences are, first, that in much of the southern trench the rocks and structures are similar in both flanks; second, that formations in the Rockies flank in general stand above their counterparts in the Purcell flank; and third, that not all of it is so obviously a locus of faults. Southward to latitude 49°30' the topographic form of the trench is due to erosion along a chain of parts of different faults, important among which are early thrust faults that trend northward obliquely into, and in part across, the trench site and which influenced later movements. S. of latitude 49°30' the topographic form of the trench may be due fundamentally to block faulting. --Auth.

1-2944. Bronlund, E. A SURVEY OF KNOWN MINERAL DEPOSITS IN THE NORTHERN ROCKY MOUNTAIN TRENCH (In: Holland, Stuart S., and others. Symposium on the Rocky Mountain Trench: Can. Mining & Metall. Bull., v. 52, no. 565, p. 333-335, May 1959).

Placer gold has been recovered from near Parsnip River, McLeod Lake area, in the S. to beyond Fox River in the N. Mica is the only nonmetallic mineral of much significance; it occurs in or near pegmatites and mica schists in the Butler Range W. of Fort Grahame. Base metal deposits occur in the Lower Cambrian belts on both sides of the trench, but the southwesterly belt contains most of the known mineral deposits. --M. Russell.

1-2945. Lundberg, Hans T. GEOPHYSICAL METHODS USED IN MINERAL EXPLORATION OF THE ROCKY MOUNTAIN TRENCH (In: Holland, Stuart S., and others. Symposium on the Rocky Mountain Trench: Can. Mining & Metall. Bull., v. 52, no. 565, p. 336, May 1959).

In 1958 nearly 75,000 sq. mi. of northeastern British Columbia was covered by airborne reconnaissance surveys. A prerequisite was a 1:50,000-scale topographic map, prepared by enlarging portions of the National Topographic series (Canada). Two airborne survey methods, magnetic and radiometric, were used. Gravimetric or electromagnetic methods may be added when further confirmation of anomalies are needed. The ratiograph method is often used to define contacts and outline bodies of base metals. --M. Russell.

1-2946. Aho, Aaro E. SIMILAR TRENCHLIKE LINEAMENTS IN YUKON (In: Holland, Stuart S., and others. Symposium on the Rocky Mountain Trench: Can. Mining & Metall. Bull., v. 52, no. 565, p. 337-338, May 1959).

In Yukon, the regional Shakwak, Teslin, and Tintina lineaments are very similar to the Rocky Mountain Trench in dimensions and physiographic characteristics... These trenchlike lineaments strike more westerly (about N. 50°-55°W.) than the Rocky Mountain Trench but similarly lie nearly parallel to, or at a small angle to, the regional grain of the Cordillera. They separate or bound the main competent Precambrian and batholithic belts. Many of the other major lineaments or faults in Yukon lie parallel or subparallel to the 3 trench features. --Auth.

1-2947. Anderson, Alfred L. GEOLOGY AND MINERAL RESOURCES OF THE NORTH FORK QUADRANGLE, LEMHI COUNTY, IDAHO: Idaho Bur. Mines & Geology, Pamph. 118, 92 p., 15 figs. incl. 5 maps (geol. map in pocket, scale 1 in. to 1 mi.), secs. (in pocket), July 1959, 20 refs.

The North Fork quadrangle covers the northern end of the Salmon basin and the bordering slopes of the Beaverhead Range and Salmon River Mountains. Except for 2 small granitic stocks, one on each slope, the mountains are carved largely in the Lemhi and Swauger quartzites, thick members of the Precambria Belt series. The basin is floored by 5 unconformable Tertiary formations ranging from Eocene (or Paleocene) to middle Miocene; namely, the Kriley, Challis volcanics, Kenney, Geerston, and Kirtley formations.

The Precambrian rocks have been complexly folded and faulted. Early in the Laramide orogeny, they were deformed into broad northeasterly trending folds. Later, they were subjected to stronger forces from a southwesterly direction with superposition of prominent northwestward trending folds, low-angle thrusts, high-angle thrusts, and high-angle normal faults on the earlier NE. structures.

After accumulation of the Challis volcanics on a deeply dissected early Tertiary erosion surface, normal faulting blocked out the ancestral Salmon basin and provided for the accumulation of the 3 younger Tertiary formations. Uplift of a Pliocene erosion surface at the close of the Tertiary resulted in the diversion of the northeasterly flowing Salmon River W. to the Snake and Columbia rivers, and provided the setting for the formation of ice caps on the mountain summits during the Pleistocene.

Mineral resources include small Au-quartz veins and lodes; large, low-grade, galena-bearing quartz lodes; small thorite replacement lodes, and extensive gravel deposits. --Auth.

1-2948. Reid, Rolland R. RECONNAISSANCE GEOLOGY OF THE ELK CITY REGION, IDAHO: Idaho Bur. Mines & Geology, Pamph. 120, 74 p., 62 figs. incl. 2 maps (geol. map in pocket, scale approx. 1

in. to 1 mi.), sec. (in pocket), Oct. 1959, 62 refs.

Belt-equivalent(?) NW.-trending gneisses, quartzites, and schists in the Elk City region contain 4 lineation sets (axes of small folds), representing 4 postulated regional metamorphic episodes, and 3 sets of major superposed folds.

All 3 sets of folds developed about axes that trend N. 10°-20°W. on the average. The fact that the axes in individual outcrops are not parallel, means that the rock has triclinic symmetry. This conclusion is borne out by preliminary quartz fabric studies.

Nonfolded quartz diorite to granodiorite dikes, showing the dilation offset characteristic of dikes produced by liquid magmatic injection, cut the above-described structures. These dikes are tentatively correlated with the emplacement of the magmatic part of the Idaho batholith. (The suggestion, made earlier by others, of a replacement origin for parts of the Idaho batholith, is renewed herein.) Although all 3 metamorphic episodes appear to be pre-Idaho batholith in age, it is not known whether 1, 2, or 3 orogenies are represented.

Cataclastic microchevron folds, present locally, reflect the fourth metamorphic episode, tentatively assigned to the Laramide.

Erosion in post-Challis, pre-Columbia River basalt time produced the Idaho "peneplain." Later faulting, perhaps in the Miocene, produced basins in which gravels and other basin deposits accumulated. During and after post-gravel faulting, major portions of the principal streams in the area gained their courses along NW.-trending fault zones. Renewed uplift has rejuvenated these streams, perhaps in the later part of the Tertiary. --Auth.

1-2949. Rigby, J. Keith. THE ROCKS AND SCENERY OF CAMP MAPLE DELL, UTAH COUNTY, UTAH: Utah Geol. & Mineralog. Survey, Bull. 67, 55 p., 21 figs. incl. illus., 4 maps, 3 charts, sec., 4 diags., Aug. 1959, 12 refs.

Camp Maple Dell of the National Parks Council of the Boy Scouts of America is located in southern Utah County, Utah, in the southern Wasatch Mountains. Within the camp area and in the surrounding mountains, features related to glacial, fluvial, and lacustrine erosion and deposition can be seen. The camp itself is situated on rolling hummocky topography related to slumping and other forms of mass movement. Features related to Pleistocene Lake Bonneville are well developed at the foot of the mountains in which Maple Dell lies.

Rocks ranging from Precambrian to Tertiary ages, predominantly Cambrian and Mississippian, occur within hiking distance of Maple Dell and display an array of sedimentary, igneous, and metamorphic rocks. Characteristic suites of fossils occur in most formations near the camp area but are most prolific in middle Mississippian and Lower Pennsylvanian rocks.

Faults of several varieties and large folds are well exposed E. and W. of Maple Dell and show particularly well on the N. side of Rock Creek, E. of camp.

A section of the bulletin is devoted to brief description and illustration of some of the common fossils of the area, giving both taxonomic position and stratigraphic occurrence.

Regional topographic and geologic maps are presented in addition to a large-scale map of the camp area which can be used for scouting activities. --Auth.

1-2950. Ritzma, Howard R. GEOLOGIC ATLAS OF UTAH. DAGGETT COUNTY: Utah Geol. & Mineralog. Survey, Bull. 66, 111 p., 15 illus. (6 col.), 15 maps (8 col.), 3 charts, 7 secs., Sept. 1959, 105 refs.

Daggett County is located in northeastern Utah adjacent to Wyoming on the N. and Colorado on the E. It is one of the smaller counties of Utah and the least populated.

The general area is of importance in the history of the early West... Early exploration and study by Powell, King, Hayden, Emmons, and others in the late 1860's resulted in important advances in the sciences of geology and geomorphology.

The Uinta Mountains and the Green River dominate the geography of Daggett County and its scenery. The Uintas trend from W. to E. across the southern portion of the county, with the southern county boundary following the crest line of the range for much of its distance. The county thus lies almost completely on the N. flank of the Uintas, considerably isolated from the rest of Utah. The winding course of the Green through a series of spectacular canyons and open valleys - Flaming Gorge, Horseshoe Canyon, Hideout Canyon, Red Canyon, Little Hole, Browns Park - has further segmented the county and increased its isolation.

Daggett County has a remarkably complete sequence of rock formations. The core of the Uinta Range exposes more than 20,000 ft. of Precambrian quartzitic sandstone and argillite, the Uinta Mountain group. It is proposed that the older Precambrian rocks of previous studies, the Red Creek quartzite (or complex), are metamorphosed equivalents of the Uinta Mountain group sediments. The Uinta Mountain group sediments are generally dark red, a color which dominates much of the county's landscape.

Flanking the core of the Uinta Mountains the Paleozoic and Mesozoic rocks form a colorful, spectacular series of hogbacks and strike valleys. On the S. flank in Daggett County are small exposures of the Upper Cambrian Lodore formation unconformably overlain by the Mississippian Madison and Deseret limestones. Representative of the Ordovician, Silurian, and Devonian systems are missing. On the N. flank the Mississippian rocks rest directly on the Precambrian Uinta Mountain group quartzites. The Mississippian formations are in ascending order: Madison limestone, Deseret limestone, and Humbug formation. The Mississippian-Pennsylvanian boundary lies within the Manning Canyon formation which overlies the Humbug. The Pennsylvanian system is represented (in ascending order) by the Round Valley limestone, the Morgan formation, and the Weber sandstone. The uppermost Weber beds are probably Permian. The Park City formation of Permian age, containing important phosphate beds, overlies the Weber.

The Mesozoic rocks of Daggett County form the most colorful scenery along the Uinta's N. flank. The Triassic and Jurassic formations are typical and equivalent of similar formations over extensive areas of eastern and southern Utah. In ascending order these formations are: Triassic Moenkopi formation, Chinle formation with its basal Shinarump conglomerate, Jurassic Navajo sandstone, Carmel formation, Entrada sandstone, and the Curtis and Morrison formations. The upper portion of the Morrison is probably Lower Cretaceous in age.

Upper Cretaceous rocks in Daggett County consist of a basal conglomeratic sandstone, shale, and coaly sequence here called the Dakota formation. It is overlain by the 6,900-ft. thick Mancos shale which is subdivided into the basal Mowry shale member, the thin Frontier sandstone member which in turn is overlain by the main body of the Mancos shale, some 6,500 ft. thick. Overlying the Mancos is the Mesaverde formation, here about 2,000 ft. thick. The 2 formations intertongue, with the lower Mesaverde sandstones tonguing into Mancos shale to the E. The upper Mancos beds and the Mesaverde formation can be related to equivalent formations to the N. in the Rock Springs uplift.

The early Tertiary formations of Daggett County consist of the detrital material from the Paleocene positive area centered at the E. end of the Uinta Mountains and the Uinta Mountains proper. The basal formation is the Hiawatha member of the Wasatch formation of Paleocene-Eocene age. Overlying it are the Tipton tongue of the Green River formation, the Cathedral Bluffs member of the Wasatch formation, and the main body of the Green River formation, all of Eocene age. All have complex intertonguing relations coincident with structural episodes of the rising Uinta arch and fluctuation of the fresh-water lake that occupied the Bridger segment of the Green River basin to the N.

A significant stratigraphic gap occurs between the Eocene and Miocene rocks. Late Tertiary formations (Miocene and Pliocene) are the gravel deposits which cap the Gilbert Peak and Bear Mountain erosion surfaces and the largely wind-deposited sandstones and volcanic tuffs of the Browns Park formation.

Quaternary glacial deposits radiate outward from extinct glacial centers in the high Uintas. Quaternary and Recent fluvial deposits are scattered across the county along stream courses.

The Uinta Mountains are the topographic expression of the broad regional Uinta Mountain arch. This arch coincides closely with the extent and trend of the ancient quartzite-argillite mass known as the Uinta Mountain group and is the manifestation of the movement of this "pod" of sediments as an independent block within the earth's crust. The arch is elongate W. to E. and in the Daggett County area is strongly asymmetric to the N. Rupture along the N. flank has produced 2 principal northward thrusts, the Uinta and Henry's Fork faults, both aligned W.-E. Viewed regionally the Uinta fault is a ramp thrust, steep at its "roots," shallowing northward as it involves less competent beds. Thus, the sole of the fault can vary from nearly horizontal in northerly exposures to nearly vertical in southerly exposures depending on how far erosion has stripped the overthrust sheet back to its "roots." The Henrys Fork fault is less well exposed but is probably of similar habit. The Uinta fault reaches a maximum displacement of 40,000 ft. at the Utah-Colorado border. The Henrys Fork fault displaces between 20,000 and 30,000 ft. of beds in western Daggett County.

A few subsidiary faults occur N. of the Uinta fault and between the Uinta and Henrys Fork faults. An intricate and varied pattern of faults occurs in the quartzite core of the Uinta Mountain arch. These faults show movement ranging from Precambrian to Quaternary in age.

The Uinta Mountain group of Precambrian age was deposited in a W.-E.-trending trough which ceased to be an active site of deposition in Paleozoic and later geologic time. However, the massive pod of sediments embedded in the earth's crust exerted a strong influence on subsequent structural events. During most of Paleozoic and Mesozoic time the Daggett County vicinity was part of the stable shelf area which included much of the Rocky Mountain region. Marine deposition was greatly accelerated during upper Cretaceous time. This was followed by gentle uplifting focused around the E. end of the present Uinta Mountains in uppermost Cretaceous and early Paleocene time. The Uinta "pod" then became structurally active, and the broad regional Uinta Mountai arch was upwarped in a W.-E. alignment across pre existing NW. to SE. or N. to S. folds. The Uinta folding was accomplished mostly through Paleocene time culminating in major thrusting along the NE. and N. flanks in early Eocene (Tipton) time. Structural activity then ceased abruptly, and the Uinta Mountains were subjected to extensive erosion.

In later Tertiary time, the Uinta Mountains were buried in their own detrital material high up on their flanks. Wind blown sands and thick blanketing volca ic ash added to the accumulation of encroaching sedi ment. Erosion surfaces sloped outward from the summits of the range radially into the adjacent basin Uplift in adjacent areas and the collapse of the Uinta Mountain arch forced major adjustment of stream patterns. Epeirogenic uplift of the region lowered base levels and accelerated erosion by rivers with consequent removal of vast quantities of sediments. A complex sequence of uplift, tilting, differential er sion, and stream piracy enabled the Green River to establish its paradoxical course across the Uintas. Continued regional broadwarping and lowered base levels have resulted in deeply incised canyons and exhumed mountain ranges. Pleistocene glaciation re sulted in accelerated erosion and the sculpturing of glacial cirques and valleys in the high Uintas.

Daggett County has not known metallic mineral de posits of commercial value. There are minor occur rences of Cu, Fe, U, Mn, and Au. Natural gas with minor amounts of distillate are produced from the Clay basin field. Other nonmetallic resources include small locally utilized coal deposits and possibl large undeveloped phosphate rock resources.

Flaming Gorge Dam, a major water storage and hydroelectric unit of the Upper Colorado River Storage Project, is under construction on the Green Rive in the central portion of Daggett County. The dam undoubtedly will bring sweeping changes in the geography of the entire vicinity. Extensive recreational development - water sports and fishing - and increas commercial and industrial activity are contemplated. --Auth.

1-2951. Williams, J. Stewart. GEOLOGIC ATLAS OF UTAH. CACHE COUNTY: Utah Geol. & Mineralog. Survey, Bull. 64, 98 p., 14 illus. (1 col.), 15 maps (13 col. incl. fold. geol. map & secs., sca 1/2 in. to 1 mi.), 4 secs., chart, June 1959, 64 ref

Cache County is essentially Cache Valley and its surrounding drainage area. Structurally the valley is a graben at the eastern margin of the Basin and Range province, between the northernmost element of the Wasatch Range, Wellsville Mountain, and the southern extension of the Malad Range, Clarkston Mountain, on the W., and the Bear River on the E.

Wellsville Mountain and the Bear River Range reveal a section of Paleozoic rocks tens of thousands of feet thick. All systems are represented with the pos sible exception of the Permian. The Cambrian section, with 7 formations has long been known through the studies of Walcott and others; the Ordovician sys tem is well represented, and the sole representative of the Silurian in the Rocky Mountain region, the Lak town dolomite, is well exposed. The Devonian syste is thicker and more diversified than in most western areas. The Mississippian is represented by thick de posits accumulated at the margin of the Oquirrh basin. Over 6,000 ft. of Pennsylvanian and perhaps Permian strata follow the Mississippian in this basin. Triassic rocks were probably deposited across the area, but later removed by erosion. In Jurassic tim the sea remained generally E. of the area, and the growing mountains of the Laramide orogeny rose across the future site of the valley during the Cretaceous period.

Early Tertiary rocks of the Wasatch groups are rather widely but not well exposed in the eastern parts of the county. Late Tertiary rocks of the Salt Lake group underlie foothill benches about the valley, and reach a total thickness near 9,000 ft. Pleistocene Lake Bonneville occupied Cache Valley, and its deposits control the surface geology at all elevations below 5,135 ft. The total thickness of the Lake Bonneville group, and other valley sediments younger than the Salt Lake group, is not known.

Cache Valley is believed to have been repeatedly deepened by reactivation of its boundary faults. This movement has disturbed the Salt Lake group rocks, and created the foothill benches of the valley. Two erosion surfaces related to the changing base level of the valley are recognized, the Rendezvous Peak and McKensie Flat surfaces.

Cache County geology is notable for its thick and well-exposed section of Paleozoic rocks, and for its interesting geologic structures. Its mountains are only sparingly mineralized, but their sedimentary nonmetallic resources will increase in importance. Geomorphic features due to solution have significant development in the area. --Auth.

1-2952. Hill, Patrick Arthur. **GEOLOGY AND STRUCTURE OF THE NORTHWEST TRINIDAD MOUNTAINS, LAS VILLAS PROVINCE, CUBA**: Geol. Soc. America, Bull., v. 70, no. 11, p. 1459-1478, 13 illus. on 2 pls., 4 maps (1 fold.), 6 tables, Nov. 1959, 32 refs.

The major rock types of the Trinidad mountains of central Cuba are carbonate rocks and schists of presumable Mesozoic age. Both are carbonaceous, yet devoid of fossils. The carbonate rocks comprise limestones (about 90%), brucite limestone, and dolomites.

The brucite limestone contains chloritic mica (sheridanite). The dolomites, despite lenticulation, might serve as marker horizons. Two varieties are noted, one with crystals of black euhedral gypsum, the other without them.

Most widespread of the schists is a carbonaceous chloritic mica schist which alternates with quartz-garnet-mica schist or less commonly grades into epidote or talc schists.

Serpentinites are of 2 types, a nodular type derived from peridotites, and a fine-grained type (greenstone) derived from microgabbro. The greenstone is older and has been affected by movement of 2 periods; one (preserpentinization) formed actinolite, the other (postserpentinization) locally developed magnetite-chlorite schist. Other chloritic derivatives include a goethite-chlorite schist and an albite-lawsonite-chlorite schist. The predominant chlorite is clinochlore.

All rocks are isoclinally folded. Cleavage or jointing that might serve to establish overturning is absent. Strike faults are prominent. Transverse faults, because of the lack of traceable units, are difficult to recognize.

The mountains appear to form a gigantic anticlinorium. A continuous band of amphibolite averaging 1,200 ft. in thickness separates the carbonate rocks and schists of the mountains from diorite and granodiorite to the N. Although thrusting may exist within the mountains, the large northerly directed thrust formerly postulated for the northern boundary is disproved. --Auth.

2. GEOMORPHOLOGY

See also: Geologic Maps 1-2936; Areal and Regional Geology 1-2941; Paleontology 1-2999; Sedimentary Petrology 1-3113, 1-3123; Engineering Geology 1-3188.

1-2953. Büdel, Julius. CLIMATIC ZONES OF THE PLEISTOCENE. Translated by H. E. Wright, Jr.: Internat. Geology Rev., v. 1, no. 9, p. 72-79, map, sec., Sept. 1959, 21 refs.

Although much emphasis has been placed on the effects of Pleistocene ice sheet as the determinant of Pleistocene climate in Europe, only through the combined evaluation of all useful climatic indicators can Pleistocene climatic zones be differentiated. The relationships between a paleoclimatically determined snowline and polar treelines and extent of loess deposition, determined stratigraphically, botanically, and morphologically, also indicate climatic conditions of Pleistocene Europe. Five great climatic-morphologic and plant-geographic zones, namely, forest-rubble tundra, forest tundra, loess tundra, loess steppe, and loess-forest steppe, may be distinguished. Considering these factors and their characteristics and spatial and temporal extents, it is possible to present chronologically the differentiation of the Würm glacial period independent of the retardation effect of ice sheets. --G. E. Denegar.

1-2954. Kamb, W. Barclay. ICE PETROFABRIC OBSERVATIONS FROM BLUE GLACIER, WASHINGTON, IN RELATION TO THEORY AND EXPERIMENT: Jour. Geophys. Research, v. 64, no. 11, p. 1891-1909, 3 illus., map, 21 diags., table, Nov. 1959, 27 refs.; also pub. as; California Inst. Technology, Div. Geol. Sci., Contr. no. 947.

Ice observed on the surface of Blue Glacier [Olympic National Park, Washington] is classified texturally into 3 types: coarse bubbly ice, coarse clear ice, and fine ice. The 3 types occur intercalated to form the observed foliated structure of the bulk glacier ice. Petrofabric study of fine ice reveals consistently a broad maximum in the density of c-axis orientations, centered about the pole of the foliation plane. This single-maximum fabric is in some respects similar to fabrics of stressed ice from polar glaciers, and the textures of fine ice and polar ice are similar. The fine-ice layers also resemble layers that have recently been produced by rapid shearing deformation of glacier ice in the laboratory. It is inferred that the fine-ice layers in the glacier constitute zones that are undergoing (or have recently undergone) rapid mechanical plastic flow, and that the adjacent coarse-ice layers originate by recrystallization from fine ice and are not now deforming rapidly by mechanical plastic flow (basal glide). Whether the fine-ice layers have predominately a tectonic origin or whether they originate predominately as infillings of snow in crevasses in the icefall is not known for certain.

Coarse bubbly ice fabrics generally show more than one maximum in the density of c-axis orientations. The statistical significance of multiple-maximum fabrics is tested by a comparison of several independent fabrics from given stress situations, and it is shown that the basic 4-maximum pattern is reproducible, though subject to unexplained fluctuations in orientation. The "diamond-shaped" 4-maximum pattern is characteristic of ice subjected to long-continued shear stress of persistent orientation, and the long axis of the "diamond" is (approximately) parallel to the direction of the stress vector that acts across the persistent plane of maximum shear stress. It is inferred that the basic features of the pattern develop at some depth within the glacier, and that subsequent deformation has affected the pattern to some extent.

The results of recent experimental studies of the origin of ice fabrics are in moderately good aggreement with the Blue Glacier observations. Recent theoretical treatments are in sufficient disagreement to be ruled out.

A new method of presenting orientation data allows statistical inferences to be drawn directly from the fabric diagrams. --Auth.

1-2955. Bretz, J. Harlen. THE DOUBLE CALUMET STAGE OF LAKE CHICAGO: Jour. Geology, v. 67, no. 6, p. 675-684, 2 maps, diag., Nov. 1959, 18 refs.

Correlation of the 3 stages of glacial Lake Chicago with sequential changes in level of contemporaneous glacial lakes in the Erie and Huron basins was correctly made in 4 papers by Bretz, in 1951-1955. The channel of glacial Grand River and the Allendale delta afford convincing evidence that the later correlations by Hough (1958) are in error. --Auth.

1-2956. Péwé, Troy L. SAND-WEDGE POLYGONS (TESSELATIONS) IN THE McMURDO SOUND REGION, ANTARCTICA - A PROGRESS REPORT: Am. Jour. Sci., v. 257, no. 8, p. 545-552, illus., map, diags., Oct. 1959, 41 refs.

A microrelief pattern of polygons 20 to 40 ft. in diameter occurs in the perennially frozen ground of the glacier-free lowlands of the McMurdo Sound region, Antarctica. They are similar to ice-wedge polygons in the Arctic except that they are in ground devoid of vegetation and are outlined by textural changes in the soil between the inter-polygonal furrow and the enclosed polygonal areas. The term "sand wedge" polygon is here proposed for this widespread phenomenon.

The sand wedge polygons occur in all surficial material, even in stagnant glacial ice. A transverse section across the inter-polygon trench or furrow reveals a well-formed wedge-shaped mass of structureless fine- to medium-grained sand extending 1 to 10 ft. below the surface and 1/4 to 4 ft. wide at the top, tapering down to a feather edge at the base. The sediments adjacent to the wedge have been deformed upward and may be vertical or overturned near the top of the wedge. The upwarping decreases downward.

Suggested origin of the polygons and sand wedges is similar to the origin of foliated ice wedges and polygons in the Arctic. Periodic contraction cracks in the perennially frozen ground around McMurdo Sound, cracks produced by the great change in temperature from summer to winter, are gradually filled with clean sand which filters down from above in the spring and summer. Repeated cracking and filling with sand produces a wedge-shaped filling.

Perhaps not all sand wedges reported in temperate latitudes are replacements of ice wedges as generally believed, but may be original structures formed under an arid climate similar to that which exists at McMurdo Sound today. --Auth.

1-2957. Lathbury, Alison, and Reid A. Bryson. STUDIES OF THE PHYSIOGRAPHIC FEATURES OF LAKE MENDOTA. I. SUBLACUSTRINE GULLIES: Wisconsin, Univ., Dept. Meteorology, Rept. Lakes & Streams Inv. Comm. no. 17, 28 p., 25 figs. incl. maps, charts, graphs, Dec. 1958, 9 refs.

Lake Mendota, Dane County, Wiscónsin, includes 3 areas where distinct sublacustrine gullies exist, which are analagous to submarine canyons. One of these, Governor's Island canyon, drops off from a depth of 45 ft. at its head to a maximum of 84 ft. in a plunge pool, then rises to a depth of 64 ft. at the canyon outlet. Turbidity flow is suggested to account for its origin but no conclusive evidence is available. --M. Russell.

1-2958. Finkel, Herman J. THE BARCHANS OF SOUTHERN PERU: Jour. Geology, v. 67, no. 6, p. 614-647, 9 illus. on 3 pls., 18 figs. incl. fold. map, diags., graphs, 9 tables, Nov. 1959, 39 refs.

The crescentic sand-dune formation known as the "barchan" occurs extensively in the desert coast of southern Peru. Quantitative measurements were made on 75 of these to determine relationships between height, width, and length of horns. A consistently longer W. horn was measured in most of the barchans, but this distortion cannot be readily explained. Mechanical analyses of the dune sand were performed on samples taken from the Pampa de Clemesi and the principal barchan deposits in the Pampa de la Joya, as well as from deposits further downwind from La Joya. There is a consistent increase in the proportion of the fine material in the samples taken farther from the Pampa de Clemesi. The bulk specific gravity also decreases with distance from Clemesi. Bulk specific gravity varied with dune height. Mineralogical analyses of these same samples indicate a decrease in the heavier minerals with increasing distance from the Pampa de Clemesi, and an increase in the volcanic, fibrous glass. This evidence indicated that the La Joya barchans originated from the Pampa de Clemesi and extend over a strip 100 km. downwind, unobstructed by the transversal river channels, which are from 600 to 800 m. deep.

The forward movement of the barchans was measured by superimposing 2 aerial photographs made in 1955 and 1958, adjusted to equal scale by means of ground control. For 45 barchans whose heights were measured in the field, the horizontal displacement in 3 years was found to be as follows: $1/\underline{D} = 0.00726 + 0.0037\underline{H}$. Further measurements were made on 75 other barchans, whose heights were derived from measurements of the aerial photographs, and a similar relationship was discovered. The relationship of dune height to annual forward motion is summarized as follows:

Crest height (m.)	Displacement (m.)
1.0	32.3
2.0	22.0
3.0	16.8
4.0	14.5
5.0	12.2
6.0	11.5
7.0	9.2
Average 3.67	Average 15.4

These data are strikingly in agreement with the predicted motion based on Bagnold's theory and daily wind data recorded at the nearby Vitor Air Base. The mass distribution of over 1,000 dunes was studied statistically, and certain significant mathematical relationships were derived for both the longitudinal and transverse spread of the barchans across a flat plain. --Auth.

1-2959. Krumbach, A.W., Jr. EFFECTS OF MICRORELIEF ON DISTRIBUTION OF SOIL MOISTURE AND BULK DENSITY: Jour. Geophys. Research, v. 64, no. 10, p. 1587-1590, illus., map, profile, 5 tables, Oct. 1959, 2 refs.

A plot of moderately dissected bottom-land soil in W.-central Mississippi was divided into 120 sampling areas, on each of which soil moisture samples were taken from the 6- to 12-in. layer below the surface (at point of sampling). Topography was mapped at contour intervals of 0.3 ft., and soil moisture and bulk density were analyzed in relation to microelevation. The total difference of elevation on the plot was 1.8 ft. Two shallow drainages divided the plot.

Very small changes in elevation caused significant changes in moisture and bulk density for the 6- to 12-in. layer. The variation in moisture appeared to be greater when measurements were by volume than by weight. --Auth.

3. STRUCTURAL GEOLOGY

See also: Areal and Regional Geology 1-2946; Stratigraphy 1-2971, 1-2973, 1-2978; Geophysics 1-3025; Engineering Geology 1-3185.

1-2960. Elliott, D.H. VERTICAL FAULT DISPLACEMENTS OBTAINED FROM AIRPHOTOS: Econ. Geology, v. 54, no. 7, p. 1311-1312, Nov. 1959.

The approximate vertical displacement of faults can be obtained in many cases from a stereoscopic study of vertical airphotos, using one simple measurement involving no parallax measurements. Two methods are used - the first for faults that offset beds having appreciable dip, and the second for faults that displace flatlying beds. In both cases, it is necessary to identify a specific bed on both sides of the fault.

Competent interpreters can expect a plus or minus 10% accuracy in the first method, and a plus or minus 20% accuracy in the second. The second method may also be used for estimating the height of cliffs or hills. --J. A. Chamberlain.

1-2961. Crowell, John C. PROBLEMS OF FAULT NOMENCLATURE: Am. Assoc. Petroleum Geologists, Bull., v. 43, no. 11, p. 2653-2674, 4 maps, 8 secs., 5 diags., Nov. 1959, 13 refs.

The distinction between separation and slip is fundamental to the proper geometric understanding of fault displacements. Ideally geologists strive to find slip, the relative displacement of formerly adjacent points on opposite sides of a fault. In practice we recognize these points where lines formed by geological elements meet the fault plane at piercing points. Such lines are primarily those formed: 1) by intersecting planes, such as dikes transecting strata; 2) by the trace of one plane against another, as where a bed meets an unconformity; 3) by linear geologic features, such as attenuated sand lenses, ore shoots, and stream courses; 4) by stratigraphic lines, such as pinch-out lines, lines of facies changes, and fossil shorelines; 5) by constructed lines, such as isopachs, lithofacies lines, and traces of axial surfaces with bedding.

Not always are such data in 3-dimensional space available to determine slip. Usually we have only information on displaced planes, such as bedding planes, unconformities, dikes, sills, contacts, etc., and lack recognizable lines lying within these planes. Furthermore, data are commonly given in 2 dimensions only. More widespread recognition that we must describe the geometry of fault displacements in terms of separation is therefore necessary. Moreover, since separation measures the displacement of traces of displaced planes as shown on a cross section or map, it is as essential to define the orientation of this view as to describe and give the location, amount, and sense of the separation. Where we employ the term apparent in fault definitions, in general we refer to separation.

Geologists must therefore distinguish habitually between geological situations with displaced lines and those with displaced planes. Our fault practice and terminology fail to draw this distinction sharply, so that faults are inadvertently described incorrectly when slip terms are applied carelessly to separation. A qualified committee of geologists should now examine our fault nomenclature and make recommendations that will dispel ambiguities. Precise definitions would also stimulate the search of geological data for clues to slip that alone can reveal significant facts on deformation kinematics. --Auth.

1-2962. Choquette, A.L. THEORETICAL APPROACH TO FOOTHILLS AND MOUNTAIN DEFORMATION OF WESTERN ALBERTA: Alberta Soc. Petroleum Geologists, Jour., v. 7, no. 10, p. 234-237, map, diag., Oct. 1959.

Recent drilling has shown that foothills and mountain deformation in Alberta may have begun as a large overthrust similar to the adjacent Lewis overthrust. Subsequent compression of the overthrust mass has folded and faulted the original sole thrust and formed a series of imbricate faults in the overlying sediments. --Auth.

1-2963. Atwater, Gordon I., and McLain J. Forman. NATURE OF GROWTH OF SOUTHERN LOUISIANA SALT DOMES AND ITS EFFECT ON PETROLEUM ACCUMULATION: Am. Assoc. Petroleum Geologists, Bull., v. 43, no. 11, p. 2592-2622, 15 maps, 8 secs., Nov. 1959, 7 refs.

Data obtained from recent intensive and deep drilling on piercement salt domes of southern Louisiana demonstrate that many salt domes of that area exhibit structural configurations which differ considerably from those conforming with generally accepted concepts of salt-dome growth and from results of scale-model studies.

The domal cores of many of the salt-dome structures of the lower Gulf Coast are composed of intrusive salt and contorted, brecciated, intrusive shale, of deep-water marine facies of diverse age, which is encountered stratigraphically and structurally far above its normal position. Where present, this intrusive deep-water marine shale, termed "diapiric shale" in a system of terminology proposed herein, performs the same function as does the salt core itself in providing the upstructure seal against which the less disturbed bedded sands and shales pinch out and terminate. The diapiric shale is interpreted as having breached, just as has the salt, the overlying sediments as a result of the impetus imparted to it by the buoyant energy of the associated diapiric salt. A study of the Valentine dome of southeastern Louisiana presents a good example of the nature of the domal core of many of the salt domes of this region; the diapiric shale component of this domal core has actually flowed higher than has the diapiric salt, showing its intrusive nature and demonstrating that it has not merely been dragged upward by the intrusive salt core.

Evidence is presented which suggests that some salt-dome structures have been developed by differential vertical movement, at various times, of localized parts of the domal core, as well as by a shift in locus of the center of uplift.

Recent deep drilling on the flanks of 3 prominent piercement salt-dome features of coastal Louisiana has shown them to be components of a much larger deep-seated parent mass of intrusive salt, for which the term "salt massif" is proposed. This salt massif has an area of 200 sq. mi. as mapped at depth of 20,000 ft., and contains 265 cu. mi. of salt down to that depth. If this massif is projected downward with vertical sides from that depth to 50,000 ft., it would contain 1,400 cu. mi. of salt. There is reason to believe that this salt massif is substantially larger than can now be proved by data obtained from drilling between it and nearby structures. The recognition of this type of major structure is important, as it marks as potentially productive many areas now considered to be off-structure or synclinal because of their apparent interdomal positions.

One of the perplexing problems encountered in the exploration and development of oil and gas fields associated with piercement salt-dome structures in southern Louisiana is the common restriction of the major reserves of a field to a single flank or segment of the structure. There appears to be no consistent preferential geographic location of these prolific segments, and their apparently random positions on the individual structures contribute greatly to the exploration of problems of piercement salt domes.

The writers believe that the causative factors of this phenomenon are closely related to the complex growth history of each dome. Detailed studies allow the reconstruction of older, fossil structures, many of them geographically discordant with the present structures, that explain the selective nature of petroleum accumulations. Examples of the relation between fossil structures and areas of present accumulation are illustrated by studies of the Weeks Island, Cote Blanche Island, Iowa, and Lake Washington fields.

Salt-dome structures of southern Louisiana, as they now exist, represent the end products of complex sedimentary and structural histories, and substantial amounts of as-yet-undiscovered oil and gas await discovery in fossil fields whose existence is obscured by present structure. --Auth.

1-2964. Green, Jack. COMPARISON OF LUNAR AND TERRESTRIAL SURFACE FEATURES: Lunar & Planetary Explor. Colloquium, Proc., v. 1, no. 5, p. 2-3, 4 illus., March, 1959, 4 refs.; also pub. as; GeoTimes, v. 4, no. 4, p. 22-23, Nov.-Dec. 1959.

Volcanic activity is preferred over impact processes to explain certain moon surface features. Photopairs compare the moon's Serpentine Ridge with a volcanic pressure ridge in Sierra Negra Caldera, Galapagos Islands, and the moon's Straight Wall with a subsidence fault, SW. side of Darwin Caldera, Galapagos Islands. --M. Russell.

1-2965. Brothers, R.N. FLOW ORIENTATION OF OLIVINE: Am. Jour. Sci., v. 257, no. 8, p. 574-584, 18 figs., Oct. 1959, 16 refs.

Petrofabric analyses of olivine indicatrix orientations in peridotites, basic plutons, and intrusive basalts have revealed a common pattern of alignment in which a concentration of α poles lies normal to a gird containing β and γ in the plane of the megascopic foliation. This fundamental pattern, together with some variations, is ascribed to laminar flow during intrusion. A similar deformation fabric is developed in olivine tectonites where the glide plane (010) of olivin is oriented parallel to the principle s surface. --Auth

1-2966. Woollard, G.P. CRUSTAL STRUCTURE FROM GRAVITY AND SEISMIC MEASUREMENTS: Jour. Geophys. Research, v. 64, no. 10, p. 1521-1544, 2 secs., 12 graphs, 6 tables, Oct. 1959, 36 refs.

Gravity data indicate that there is a regular relationship between crustal structure, crustal density (composition), and surface elevation. Earthquake and surface seismic refraction and reflection evidenc as to the composition and structure of the earth's crust have not yielded a simple, unambiguous relationship to the surface elevation. The velocity dispersion of earthquake surface waves, on the other hand, indicates variations in the thickness and composition of the crust that are in general accord with the variations in surface elevation and the Bouguer gravity anomalies. Why seismic refraction measurements have not agreed everywhere with gravity and surface wave indications of crustal structure appears to be a result of masking of crustal layering. On the basis of the slope of the curve that described the relationship between the seismic depth to the Mohorovičić discontinuity and Bouguer gravity anomalies, th density difference between the crust and the mantle appears to decrease as the thickness of the crust increases. On the assumption that the mantle has a constant mean density of 3.32 gm./cc., the mean crustal density would appear to increase from a minimum value of 2.86 gm./cc. in the oceans to about 3.08 gm./cc. beneath the high plateaus and mountains If the mean crustal density is essentially constant, th effective density of the mantle must decrease by a comparable amount. The existence of a low-density zone in the upper part of the mantle, as suggested by the velocity dispersion of very long period Rayleig waves, would explain the relationships observed. Isostatic relationships suggest that the mean density of the continental crust is essentially constant (2.85 gm./cc. to 2.88 gm./cc.). These values imply that a basaltic layer is present everywhere. That there is possibly an increase in mean crustal density as the crust thickens is suggested by U.S.S.R. seismic studies in central Asia. These show that the intermediate (basaltic) layer is usually thicker beneath areas of uplift. Although the origin of the basaltic layer can only be surmised, its general inhomogeneity, as indicated by variations of seismic velocity from 6.4 to 7.3 km./sec., and its varying thickness suggest that it may be a zone of phase transformation within the underlying mantle rock. Despite the lack of homogeneity in the crust, it appears possible that empirical relationships may be used to predict approximate crustal thickness from the regional Bouguer gravity anomalies or from surface elevations with a reliability approaching that for seismic measurements.--Auth.

1-2967. Talwani, Manik, George H. Sutton, and J. Lamar Worzel. A CRUSTAL SECTION ACROSS THE PUERTO RICO TRENCH: Jour. Geophys. Research, v. 64, no. 10, p. 1545-1555, map, sec., 5 graphs, 2 tables, Oct. 1959, 16 refs.; also pub. as: Columbia Univ., Lamont Geol. Observatory, Contr. no. 374.

A crustal section across the Puerto Rico trench, from 450 km. N. to 250 km. S. of San Juan, was deduced from seismic refraction and gravity data. The result, a refinement of previous work, was made possible through more complete seismic refraction coverage and a program for high-speed electronic computation of 2-dimensional gravity problems. On the basis of refraction data, the crust was divided into 5 layers having compressional wave velocities of 1.54, 2.1, 3.8, 5.6, and 7.0 km./sec. Densities taken from a density-velocity curve compiled by Nafe and Drake are 1.03, 2.0, 2.4, 2.7, and 3.0 gm./cc., respectively. Depths to the Mohorovičić discontinuity were computed from the gravity data using subcrustal density of 3.4 gm./cc., which corresponds to 8.2 km./sec. on the density-velocity curve. (A similar calculation was made using a subcrustal density of 3.3 gm./cc.). Depth to M under the trench is about 20 km. decreasing sharply on both sides. Northwards, it reaches a minimum of about 10 km. under the outer ridge and then deepens gradually to about 13 km. beneath the southern margin of the Nares basin. S. of the trench M rises under the Puerto Rico shelf to about 17 km. and then deepens sharply to about 30 km. beneath Puerto Rico. S. of Puerto Rico the depth decreases again to about 14 km. under the Venezuelan basin.

Depths to M were also obtained by using Airy isostatic anomalies and assuming constant crustal density of 2.67 gm./cc. over a mantle of density 3.27 gm./cc. The crustal section thus deduced differs significantly from that obtained when the density structure within the crust was considered.--Auth.

1-2968. Harris, H.D. LATE MESOZOIC POSITIVE AREA IN WESTERN UTAH: Am. Assoc. Petroleum Geologists, Bull., v. 43, no. 11, p. 2636-2652, 5 maps, sec., 7 diags., Nov. 1959, 10 refs.

Throughout most of the eastern Great Basin major parts of the stratigraphic section have been removed by erosion. In general, effusive volcanic rocks of early Tertiary age overlie strata ranging in age from Precambrian to Permian. Because sedimentary rocks of Mesozoic and early Cenozoic age are generally absent it has been difficult to interpret the geologic history of these eras. Individual units and sequences of the early Tertiary volcanic rocks have been correlated over most of the eastern Great Basin and western Colorado Plateau. These rocks provide a valuable datum for the deciphering of the structural and stratigraphic evolution of the region.

Study of the contact relations of the volcanic rocks with older rocks indicates the existence of a linear positive element in western Utah, called herein the Sevier arch, during the late Mesozoic era. The axis of this arch trends generally NE. and is more or less parallel with the axis of the Manhattan geanticline of central Nevada and the early Cordilleran geanticline of eastern Nevada that became positive in Devonian and latest Paleozoic time respectively. The Sevier arch thus appears to be the third of a series of major upwarps developed by eastward progression of Paleozoic and Mesozoic orogenies.

It is convenient to describe the tectonic development of the Sevier arch in 6 stages. Stage I was represented by deposition of Triassic and Jurassic sediments westward as far as the early Cordilleran geanticline. Stage II was initiated by linear uplift of the Sevier arch that extended from W.-central Utah into southern Nevada. Material eroded from the arch was transported eastward into the Rocky Mountain seaway to form the thick clastic formations of latest Jurassic(?) and Cretaceous age.

Stage III was climaxed by regional thrusting that culminated the upwarping and folding of the previous stage. Highlands produced by this phase of the orogeny extended from southern Nevada northward at least as far as N.-central Utah. Erosion of these highlands resulted in deposition eastward of material that formed rocks of latest Cretaceous and early Tertiary age.

Stage IV resulted in continued erosion that reduced the region to one of mild topographic relief. In stage V early Tertiary volcanics were deposited over the region as an extensive sheet. In stage VI late Tertiary deformation superimposed the characteristic basin-and-range-type structure upon the structural features of late Mesozoic and early Tertiary age.--Auth.

1-2969. Tatevosyan, L.K. SEVERAL FEATURES OF THE DEEP STRUCTURE OF THE EARTH'S CRUST IN AZERBAYDZHAN FROM GRAVIMETRIC DATA: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 5, p. 363-366, 2 secs., pub. Sept. 1959, 10 refs.

This summarizes and interprets the results of gravity surveys made in the Azerbaydzhan S. S. R. during the last 25 to 30 years. Three major discontinuities in density are observed in the regional profile: between the Cenozoic (2.3 g. per cm.^{3}) and Mesozoic formations (2.6 g. per cm.^{3}); between the granitic complex (2.6 g. per cm.^{3}) and basaltic layer (2.9 g. per cm.^{3}); and between the basaltic layer and the Mohorovičić surface (3.3 g. per cm.^{3}).

The maximum gravity anomaly, in the Talysh region, is caused by a decrease in thickness of the sedimentary rocks, the presence of the denser granitic complex, and the approach of the basaltic layer to within 4.5 to 5 km. of the surface. The minimum, on the Apsheron peninsula, is caused by the deepening of the basement under a thick accumulation of sediments. The Δg curve observed in the Talysh-Apsheron profile mainly reflects the contour of the basaltic layer; the effect of the Mohorovičić surface is secondary in importance.--S. T. Vesselowsky (courtesy Geophysical Abstracts 175-219).

4. STRATIGRAPHY AND HISTORICAL GEOLOGY

See also: Structural Geology 1-2968; Paleontology 1-2986, 1-2992; Geochemistry 1-3058, 1-3064, 1-3066, 1-3067; Sedimentary Petrology 1-3115, 1-3123.

1-2970. Bell, W.A. STRATIGRAPHY AND SEDIMENTATION OF MIDDLE ORDOVICIAN AND OLDER SEDIMENTS IN THE WRIGLEY-FORT NORMAN AREA, MACKENZIE DISTRICT, N.W.T.: Can. Mining & Metall. Bull., v. 52, no. 561, p. 3-18, 5 illus., 2 maps, 2 cross secs., table, Jan. 1959, 34 refs.

The area lies in a great synclinorium made up of 3 physiographically important features, the Mackenzie Mountains, the Mackenzie River lowland, and the Franklin Mountains. The total stratigraphic section of the area consists of approximately 18,000 ft. of sediments ranging in age from Precambrian to Tertiary. The following formations are described in detail: Precambrian; Mount Clark (Lower Cambrian); Mount Cap (Middle Cambrian); Saline River (Upper Cambrian). Shallow and often restricted seas probably prevailed in the Wrigley-Fort Norman area until the end of Cambrian time, after which they deepened considerably. The early detrital sediments were probably derived mainly from the E. Gypsum, salt, oil, Au, Pb, and Zn are potentially of economic importance in the area. --M. Russell.

1-2971. Huffman, George G. PRE-DESMOINESIAN ISOPACHOUS AND PALEOGEOLOGIC STUDIES IN CENTRAL MID-CONTINENT REGION: Am. Assoc. Petroleum Geologists, Bull., v. 43, no. 11, p. 2541-2574, 12 maps, Nov. 1959, 64 refs.

Major tectonic features of the central mid-continent area are outlined and their relation to present thickness and distribution of pre-Des Moinesian strata is discussed.

Cambro-Ordovician "Arbuckle group" thickens southward from zero along the Nemaha and central Kansas uplifts to nearly 7,000 ft. in southern Oklahoma. The Simpson, with maximum thickness of 3,000 ft. in southern Oklahoma, thins northward by convergence and overlap of younger units to extinction in northwestern Kansas. Viola-Fernvale thins northward from 1,500 ft. in Anadarko basin to 200 ft. in southern Kansas, and thickens to 400 ft. in Salina basin.

The Sylvan-Maquoketa is limited to 2 areas, one in Oklahoma, the second in northeastern Kansas. Maximum thickness in Oklahoma is 600 ft., in Kansas about 150 ft. Distribution of Hunton resembles that of Sylvan; maximum thickness exceeds 1,500 ft. in Oklahoma and 650 ft. in Forest City basin Woodford-Chattanooga lies with regional unconformity on units from Precambrian through Hunton. A 600-ft. maximum is postulated for the Anadarko basin; 50-100 ft. covers eastern Oklahoma and Kansas. Mississippian limestones are widespread with 4,000 ft. in Anadarko basin, 1,600 ft. in Hugoton embayment, and zero in northern Kansas.

Lower Pennsylvanian Springer is limited to a narrow belt in Anadarko and McAlester basins with maximum of 4,000 ft. near Ardmore. Overlying Morrow overlaps Springer, reaching maximum of 1,500 ft. in McAlester basin and more than 4,300 ft. in Anadarko basin. Distribution of Atoka resembles that of Morrow with 5,000 ft. maximum in the Anadarko basin and approximately 8,000 ft. in the McAlester basin. Widespread Des Moinesian sediments rest with marked unconformity on Atokan and older rocks.

Epeirogenic movements were mild throughout early Paleozoic with geosynclinal development in southern Oklahoma. Eustatic changes produced major unconformities and offlap-overlap relations. Strong warping occurred in post-Hunton, pre-Chattanooga time. Major orogenic movements are post-Mississippian, pre-Des Moinesian with maximum movement in late Morrowan. Final structural development took place in late Cretaceous and early Tertiary. Throughout much of Paleozoic time, the axis of maximum deposition in southern Oklahoma paralleled the Wichita Amarillo trend in the "Wichita embayment."--Auth.

1-2972. Nygreen, Paul W. THE OQUIRRH FORMATION. STRATIGRAPHY OF THE LOWER PORTION IN THE TYPE AREA AND NEAR LOGAN, UTAH: Utah Geol. & Mineralog. Survey, Bull. 61, 67 p., 6 illus., 2 maps, sec., 3 tables, Feb. 1958, 97 refs.

Detailed descriptions of the thick (26,000 ft.) Pennsylvanian-Permian Oquirrh formation are lackin Detailed study of the lowermost portion reveals the formation is divisible into at least 2 members. The lower limestone member (West Canyon member) is 1,456 ft. thick in the type area and 510 ft. thick near Logan. The "sandy" member constitutes the upper part of the formation. Studied in detail were 3,663 ft. of this upper member in the Oquirrh Mountains and 1,121 ft. near Logan.

Despite a very limited number of lithologic types, the formation is far from monotonous in sedimentary character. Remarkable bipartite cycles and various rhythmic patterns characterize the "sandy" member and are described in detail. Fusulinid occurrences indicate a preferred placement within the sedimentary cycles. Other sedimentary features include cross-bedding, pseudobreccias, ripple marks, slum structures, and graded bedding.

An important lower Pennsylvanian Chaetetes zone is present, and an age zonation, based on fusulinids, is presented. Morrow and lower Des Moines (Krebs group) age rocks are present. No Atokan fusulinids were found although rocks of this age are probably present.

Near Logan, the presence of the Des Moines fusulinid Wedekindellina in beds previously dated as Morrow corrects this error. Correlations are made wit lower Pennsylvanian formations of the Rocky Mountains. --Auth.

1-2973. Picard, M. Dane. ISOPACHOUS RELATIO AND PROBABLE WARPING DURING LATE PENNSYLVANIAN TIME IN THE ANETH AREA, SAN JUAN COUNTY, UTAH: Four Corners Geol. Soc., Bull. no. 1, [23] p., 11 maps, 3 secs., Apr. 1959, 29 refs.

The isopachous method of study of structural evolution has been applied to the Aneth field. The following Pennsylvanian stratigraphic units, in descending order, are pertinent: the upper member of the Hermosa formation (Honaker Trail formation), the Bluff (Ismay) zone, and the Desert Creek zone.

The Paradox basin was partly bounded by the Emery, Uncompahgre, San Luis, and Defiance uplifts during the time of deposition of the upper member of the Hermosa formation and the underlying Desert Creek zone. Locally, including the Aneth, McElmo Creek, White Mesa, and Ratherford fields, the present structure at the base of the Bluff (Ismay) zone is a NW.-trending, horseshoe-shaped, fold and "reef-like" development, opening NW. Aneth is a NW.-trending anticline with 2 highs on the crestal portion.

The major portion of this paper presents the results obtained by isopaching cumulative stratigraphic intervals, while retaining a constant lower datum, and progressively raising the upper datum. Theoretically this procedure effectively portrays the stages in structural growth of the lower datum at the time of deposition of each successively higher (or younger) datum.

The base of the Bluff (Ismay) zone was selected as the lower datum and the younger successive datums - radioactive log correlation points - used in the study were: top of Bluff (Ismay) zone, "main carbonates," and "upper Hermosa." The Desert Creek zone was also isopached and ranges from about 122 to 200 ft., attaining its maximum thickness in the southeastern part of the field.

The following conclusions, resulting from interpretation of the isopachous data, outline the structural evolution of the Aneth area during late Hermosa time: 1) The structure at the end of Bluff (Ismay) zone deposition was possibly anticlinal. 2) Extremely minor structural growth along with draping and compaction probably continued throughout deposition of the "main carbonates." Several subsidiary folds were present by the end of "main carbonates" time. 3) By the end of "upper Hermosa time" the general structural form and all the subsidiary folds were developed. Crustal movement was more pronounced during deposition of the upper 300 ft. of the upper member of the Hermosa formation.

The present structural form of the Aneth area results from mild anticlinal warping that apparently began near the end of Desert Creek time, and during the Pennsylvanian continued intermittently throughout upper Hermosa time. Related sedimentary compaction may have been a factor, and probably was responsible for about 30% of the observable structure. However, most of the present structural relief is due to post-upper Hermosa deformation, much of which may have been associated with the Laramide orogeny. --Auth.

1-2974. Burnside, R.J. GEOLOGY OF THE HORSESHOE ATOLL IN BORDEN AND HOWARD COUNTIES, TEXAS: U.S. Geol. Survey, Prof. Paper 315-B, p. 21-35, illus., 2 maps (1 in pocket), 3 secs. (in pocket), 2 logs, 3 tables, 1959, 34 refs.

The Horseshoe atoll is an arcuate mass of deeply buried fossiliferous limestone of Pennsylvanian and early Permian age in the Midland basin of W. Texas. The southern part of the atoll is in southern Borden and northern Howard counties. From early Strawn until early Wolfcamp time this atoll, which had some of the characteristics of a reef, was a prominent feature on the floor of the Midland basin. The crest of the atoll is a series of buried hills and saddles. In the area of this report, 10 oil fields have been found in the hills along the crest, 2 on spurs on the flank of the atoll, 2 in the distant seaward area, and 2 on the flank occupied by the central lagoon.

Calcilutite, calcarenite, and calcirudite comprise most of the reef rock, but there are a few thin beds of shale. The complex facies relations and stratigraphy of this reef are best explained as effects of oscillation of sea level during the time of reef growth. The cementation of the reef and subsequent development of porosity can be explained by the same oscillations of sea level, plus leaching by ground water during the periods of emergence. Reef growth was terminated in early Wolfcamp time when large volumes of fine-grained terrigenous sediments were deposited in the area.

The oil probably accumulated during Wolfcamp time shortly after the atoll was covered by black shale. Some peculiarities in the observed distribution of oil in the atoll may be explained by the apparent stratification of porosity. --Auth.

1-2975. Norris, D.K. TYPE SECTION OF THE KOOTENAY FORMATION, GRASSY MOUNTAIN, ALBERTA: Alberta Soc. Petroleum Geologists, Jour., v. 7, no. 10, p. 223-233, 237, 2 maps, sec., Oct. 1959, 13 refs.

The type section of the Kootenay formation [Cretaceous] is proposed on the S. face of Grassy Mountain, 5 mi. N. of Blairmore, Alberta. There the formation is split into 4 units, termed respectively, from the lowest, the Moose Mountain, Adanac, Hillcrest, and Mutz members.

The lower contact of the formation is gradational and is drawn to include the characteristically gray, carbonaceous, micaceous sandstones with platy siltstone interbeds in the Kootenay formation, and the brown, strongly limonitic sandstones with thin, rubbly weathering mudstone interbeds in the Fernie group. The upper contact of the formation, as in previous usage, is defined as the base of the lowest massive chert-pebble conglomerate of the Blairmore group. --Auth.

1-2976. Eargle, D. Hoye. STRATIGRAPHY OF JACKSON GROUP (EOCENE), SOUTH-CENTRAL TEXAS: Am. Assoc. Petroleum Geologists, Bull., v. 43, no. 11, p. 2623-2635, map, table, Nov. 1959, 26 refs.

Discovery of U and renewed exploratory activity for oil and gas in the outcrop area of the Jackson group of Eocene age in S.-central Texas require setting up a standard nomenclature for rocks of the group in that area. In general, the names which Ellisor proposed in 1933 have been used, but modified to agree with current usage by most geologists.

The Jackson group, as proposed, consists of 4 formations, in descending order: Whitsett, McElroy, Wellborn sandstone, and Caddell. The Whitsett formation, comprising the Fashing clay, Calliham sandstone, Dubose, and Stones Switch sandstone members, consists chiefly of bentonitic clays and tuff near the top and sandstones near the base. The McElroy formation consists of the Conquista clay (a new name substituted for the pre-empted name Falls City shale of Ellisor), the Dilworth sandstone, and the Manning clay members. The Wellborn sandstone and the clayey Caddell formation are indivisible into members in S.-central Texas. --Auth.

1-2977. Carr, Wilfred J., and Douglas C. Alverson. STRATIGRAPHY OF MIDDLE TERTIARY ROCKS IN PART OF WEST-CENTRAL FLORIDA: U.S. Geol. Survey, Bull. 1092, 109 p., 3 pls. (maps) in pocket, 16 figs. incl. 2 maps, secs., diags., graphs, 4 tables, 1959, 61 refs.

Petrographic studies of the Suwannee limestone (Oligocene), Tampa limestone (lower Miocene), and Hawthorn formation (middle Miocene) yielded data that are useful for correlation in a region where weathering has thoroughly altered the rocks. Mechanical analysis of sand aided in the recognition of formations in weathered exposures. An efficient laboratory method for insoluble-residue and mechanical analysis of sand was developed. Preliminary work indicates that the kind and distribution of heavy minerals, clay minerals, and chert should also be valuable in any further stratigraphic studies of this area.

Mapping of rocks of Oligocene and Miocene age in

Hillsborough, Pasco, and Polk counties has extended the known limits of the Tampa limestone northeastward; some of the sand and clay previously mapped as Hawthorn formation in northeastern Pasco County belongs to the Tampa. Sand of the Hawthorn formation is coarser than that of the Tampa limestone. Although phosphate nodules are not normally present in the Tampa, they are abundant in places, particularly in Polk County. A contact between calcareous and noncalcareous parts of the Hawthorn was mapped in northern Hillsborough and Polk counties. More than 50 new localities were examined.

Structure contours on the base of the Hawthorn formation, and other evidence from well logs and surface exposures suggest an unconformity between the Tampa limestone and Hawthorn formation. A fault that brings rocks of Eocene age adjacent to the Suwannee and Tampa limestones is believed present in northwestern Polk County. The Suwannee limestone appears to be absent E. of this structure.

Weathering in this part of Florida results in local concentration of Fe, P, Al, and silica. Secondary chert and aluminum phosphate zones form where the parent material is favorable. Leaching forms a weathering profile of increasing solubility downwards, which typically contains, from top to bottom, quartz sand, Fe-stained clayey sand with chert and Fe and phosphatic hardpans, blue-green sandy clay with local calcium phosphate nodules, and a thin zone of slightly calcareous clay passing abruptly into limestone. The presence of a substantial amount of secondary chert in a weathered section is believed to be evidence that limestone was formerly present. Crenulated bedding, common in weathered exposures in the area, is probably a result of solution of limestone and differential settling of the residue. The presence of weathering products such as chert and aluminum phosphate below beds of virtually unleached limestone suggests periods of intraformational weathering.

Zones consisting of material weathered from the Suwannee limestone are relatively thin and nonphosphatic, and there is a high proportion of clay to sand and much chert. Material weathered from the Tampa limestone typically shows local silicification and contortion of bedding, and contains clayey residues that are generally low in phosphate. Residue of the Hawthorn formation is commonly phosphatic, lacks chert, and contains a few quartz sand grains that are conspicuously coarser than normal.

Fauna and petrography suggest a shifting lagoonal, insular, and locally fresh-water environment of deposition for the Tampa limestone. Open sea and relatively static conditions of sedimentation characterized Hawthorn time. The rather abrupt change in conditions of deposition from Oligocene to Miocene time, which resulted in an increase in amount and grain size of clastic material in rocks of Miocene age can be ascribed to currents carrying material into the Florida peninsula from sources to the N., and possibly to ash falls from distant volcanic activity. The period of major weathering in the area probably took place in late Pliocene or early Pleistocene, but evidence of periods of older weathering is believed to be present.

Prolonged leaching of zones rich in calcium phosphate (apatite) produces in some areas a hardpan ("leached zone") that consists chiefly of relatively insoluble aluminum phosphate minerals (wavellite, pseudowavellite, and others) that commonly retain small amounts of U. In northeastern Hillsborough County, N. and W. of the boundaries of the land-pebble phosphate deposits, a belt was found that contains zones of aluminum phosphate which resulted from leaching of phosphatic beds, chiefly of the Hawthorn formation. These zones generally have a thin overburden and a moderate U content. Phosphate or U is not present in commercial quantities in unleached limestone of this area, but the upper surface of limestone of the Hawthorn in the land-pebble phosphate district was found to contain locally nearly 20% MgO. --Auth.

1-2978. Maxwell, John C. TURBIDITE, TECTONIC AND GRAVITY TRANSPORT, NORTHERN APENNINE MOUNTAINS, ITALY: Am. Assoc. Petroleum Geologists, Bull., v. 43, no. 11, p. 2701-2719, 2 maps, 5 secs., Nov. 1959, 37 refs.

The region now occupied by the northern Apennine Mountains of Italy was deep sea from late Triassic or earliest Jurassic through much of the Miocene. In early Oligocene a trough developed parallel with the axis of the later mountain system and was filled with sediments ascribed to turbidity currents, originating at the NW. In early and middle Miocene the locus of deposition shifted northeastward; the source remained in the NW.

About the same time (late Oligocene or early Miocene) a series of submarine orogenic ridges developed, first W. of the present Ligurian-Tyrrhenian coast, then progressively NE. in Tuscany. Argillaceous and marly sediments of late Jurassic, Cretaceous, and Eocene age slid from the crests of the rising ridges in a series of great imbricate slices which became more chaotic with distance of transport NE. The tectonic ridges of Tuscany rose beneath a thick cover of the gravity-transported chaotic mass, and this allochthonous material was involved in the uplifting and faulting of each ridge. Most of the ridges are overturned and thrust NE. The youngest ridges, those of the mountain front facing the Po plain and the Adriatic Sea, came into being at the end of the Miocene or in earliest Pliocene. Thus the turbidity-current transport of vast quantities of sediment from the NW., the compressional movements and the tectonic transport NE., and the resulting gravity transport of a great chaotic mass in the same direction occurred during brief and overlapping intervals of Cenozoic time. --Auth.

1-2979. Long, Leon E., J. Laurence Kulp, and F. Donald Eckelmann. CHRONOLOGY OF MAJOR METAMORPHIC EVENTS IN THE SOUTHEASTERN UNITED STATES: Am. Jour. Sci., v. 257, no. 8, p. 585-603, 3 maps, 3 tables, Oct. 1959, 29 refs.; also pub. as: Columbia Univ., Lamont Geol. Observatory, Contr. no. 349.

K-Ar and Rb-Sr age measurements have been made on a variety of granites, pegmatites, gneisses, and schists which comprise the plutonic-metamorphic complex of the Piedmont and Blue Ridge of the southeastern United States. Large portions of the area appear to have been metamorphosed initially approximately at the same time as the Grenville province, i. e., about 900 to 1, 100 million years ago. Superimposed on this older metamorphic province was a major orogenic event culminating at about 350 million years with widespread recrystallization of existing rocks and intrusion of pegmatites in the Spruce Pine, Franklin-Sylva and Bryson City districts, and granites in the Virginia and North Carolina piedmont. There is strong evidence of an additional metamorphic epoch between 350 and 1, 000 million years, but its effects have been largely obliterated by the 350 million years event.

In western North Carolina a transition of apparent ages from 355 to 890 million years occurs in the same rock unit (Cranberry gneiss) over a distance of about 10 mi. across the strike of the border of the 350 million years event.

In the southeastern Piedmont of Georgia and South Carolina, a younger metamorphic event or events can be detected producing rocks of apparent age ranging from 230 to 310 million years. The time of these orogenies is compared with those in the central and northern Applachians.

Evidence is accumulating that the Holmes' time scale will have to be considerably lengthened. --Auth.

1-2980. Wasserburg, G.J., G.W. Wetherill, and Lauren A. Wright. AGES IN THE PRECAMBRIAN TERRANE OF DEATH VALLEY, CALIFORNIA: Jour. Geology, v. 67, no. 6, p. 702-708, 3 maps, table, Nov. 1959, 23 refs.; also pub. as; California Inst. Technology, Div. Geol. Sci., Contr. no. 946.

The Sr^{87}-Rb^{87} and A^{40}-K^{40} ages of minerals contained in 3 pre-Pahrump igneous and metamorphic rocks were determined. The results indicate an event at 1.7×10^9 years. Since the rock types investigated have distinct continental affinities, it is concluded that continental growth has not occurred in this area since that time. Concordant ages obtained on 2 rocks gave results in disagreement with the observed field relationships.--Auth.

5. PALEONTOLOGY

1-2981. Raup, David M. CRYSTALLOGRAPHY OF ECHINOID CALCITE: Jour. Geology, v. 67, no. 6, p. 661-674, 7 figs., Nov. 1959, 20 refs.

Each element of an echinoderm skeleton is a single crystal of calcite. The universal stage method is used to determine orientations of crystals in coronal plates of fossil and Recent regular echinoids. Stereographic diagrams are presented which relate crstallographic orientation to the symmetry of the echinoid skeleton. Most species exhibit 1 of 2 preferred orientations and show little variation within a single individual. In 1 of the preferred orientations, c-axes are perpendicular to the test surface; in the other, they are tangent to the test surface and are aligned longitudinally.

In the present sample, crystallographic orientation shows no variation within single genera, and most echinoid families studied have but one orientation. The 2 preferred orientations appear to have evolved independently several times during echinoid history. Preferred orientation, as an adaptation to the environment, may be related to the organism's sensitivity to light. --Auth.

1-2982. Kanakoff, George P., and William K. Emerson. LATE PLEISTOCENE INVERTEBRATES OF THE NEWPORT BAY AREA, CALIFORNIA: Los Angeles County Mus., Contr. Sci. no. 31, 47 p., 3 illus., 2 maps, Oct. 1959, 58 refs.

The largest assemblage of megafossils known from western North America is recorded from 3 localities in the 100-ft. marine terrace of the San Joaquin Hills and Newport Mesa, Orange County. About 5% of the 496 faunal constituents are extinct species, and the fauna contains a large element (representing about 12%) of locally extinct thermophilic species. The assemblage is considered to be an equivalent of the Palos Verdes sands, and the age of the fauna is inferred to be post-early Pleistocene, probably ad-Wisconsin stage. --W. K. Emerson.

1-2983. Addicott, Warren O., and William K. Emerson. LATE PLEISTOCENE INVERTEBRATES FROM PUNTA CABRAS, BAJA CALIFORNIA, MEXICO: Am. Mus. Nat. History, Am. Mus. Novitates, no. 1925, 33 p., 5 illus., 3 maps, diag., 3 tables, Feb. 1959, 49 refs.

A fauna of 107 invertebrates, mostly mollusks, was collected from the lowest marine terrace near Punta Cabras on the Pacific coast of Baja California (31°20'N.). This assemblage lived in shallow water, less than 30-35 ft. deep, in an open, rocky coast environment. Water temperatures were somewhat cooler than today as indicated by a conspicuous element of locally extinct northern species. This hydroclimate is believed to have resulted from increased rates of nearshore upwelling and a minor northward shift of isotherms. Although the fauna is essentially modern in composition, interpretation of certain C^{14} data and physiographic relationships of similar erosional surfaces near San Diego, California, suggests that the date of platform cutting and age of associated marine deposits is post-early Pleistocene, pre-Wisconsin. --Auth.

1-2984. Hertlein, Leo G., and William K. Emerson. RESULTS OF THE PURITAN-AMERICAN MUSEUM OF NATURAL HISTORY EXPEDITION TO WESTERN MEXICO. 5. PLIOCENE AND PLEISTOCENE MEGAFOSSILS FROM THE TRES MARÍAS ISLANDS: Am. Mus. Nat. History, Am. Mus. Novitates, no. 1940, 15 p., 3 illus., 2 maps, 2 tables, June 1959, 17 refs.

The presence of Pliocene and Pleistocene megafossils, mostly mollusks, is reported for the first time from María Cleofas island, the most southeasterly of this insular group. The Pliocene fauna suggests correlation with similar fossiliferous beds on María Madre island of the Tres Marías group, and the age of the beds is considered to be middle Pliocene in terms of the W. American metazoan chronology. The occurrence of fossiliferous marine terrace deposits on María Cleofas, María Magdalena, and María Madre indicates a similar geological history during late Pleistocene time for this insular group. --W. K. Emerson.

1-2985. Mook, Charles C. A NEW SPECIES OF FOSSIL CROCODILE OF THE GENUS LEIDYOSUCHUS FROM THE GREEN RIVER BEDS: Am. Mus. Nat. History, Am. Mus. Novitates, no. 1933, 2 illus., Apr. 1959.

Leidyosuchus wilsoni, n. sp., is described, illustrated, and compared with 5 previously described species. Description is based on a skull from the Eocene Green River formation near Wamsutter, Wyoming. --M. Russell.

1-2986. Simpson, George Gaylord. FOSSIL MAMMALS FROM THE TYPE AREA OF THE PUERCO

AND NACIMIENTO STRATA, PALEOCENE OF NEW MEXICO: Am. Mus. Nat. History, Am. Mus. Novitates, no. 1957, 22 p., 6 figs., Aug. 1959.

The type section of the Puerco marls of Cope and the Nacimiento group of Gardner, SW. of Cuba in the San Juan basin, New Mexico, has been of unknown age. Fossil mammals here reported show that most and perhaps all of that section is Torrejonian, middle Paleocene, in age. The terms Puerco fauna and Puercan stage and age are in general use for early Paleocene animals, rocks, and time not actually represented in the Puerco type section. It is recommended that Puercan be retained as a stage term in the current usage, but that Puerco be abandoned as a rock term and the name Nacimiento formation be used for the Puerco marls of Cope. --Auth.

1-2987. McKenna, Malcolm C., and George Gaylord Simpson. A NEW INSECTIVORE FROM THE MIDDLE EOCENE OF TABERNACLE BUTTE, WYOMING: Am. Mus. Nat. History, Am. Mus. Novitates, no. 1952, 12 p., fig., June 1959, 18 refs.

Scenopagus mcgrewi, n. gen. and sp. (Mammalia, Insectivora, Erinaceidae), is described from the Bridger formation. Allied hedgehogs and metacodonts are compared. --G.G. Simpson.

1-2988. Simpson, George Gaylord. TWO NEW RECORDS FROM THE BRIDGER MIDDLE EOCENE OF TABERNACLE BUTTE, WYOMING: Am. Mus. Nat. History, Am. Mus. Novitates, no. 1966, 5 p., fig., Oct. 1959.

Diacodon bridgeri, n. sp. (Mammalia, Insectivora, Leptictidae), is described from the Bridger formation and Viverravus cf. gracilis is recorded as new to the Tabernacle Butte faunule. --Auth.

1-2989. Simpson, George Gaylord. A NEW MIDDLE EOCENE EDENTATE FROM WYOMING: Am. Mus. Nat. History, Am. Mus. Novitates, no. 1950, 8 p., 2 figs., June 1959, 8 refs.

Tetrapassalus mckennai, n. gen. and sp. (Mammalia, Edentata, Epoicotheriidae), is described from the Bridger formation. All other known epoicotheriids are compared. --Auth.

1-2990. Hayasaka, Ichirō. FOSSIL MAMMALS FROM TAIWAN. Translated by the author: Internat. Geology Rev., v. 1, no. 9, p. 47-49, Sept. 1959, 10 refs.

Mammal fossils were first discovered on Taiwan by H. Saitō in 1926. Skulls and teeth fragments of Rhinoceros, Elephas, and Stegodon were discovered subsequently in transported float; the source bed, Tertiary gravels of the Kichō formation, was found in 1940 by Kaneko. The Tso-chen area alone has yielded specimens of all fossil mammals found in any of the 13 known fossil localities on Taiwan. Occurrences of these fossils with marine shells indicate deposition in the regressing sea of the late Pliocene. Similar fossils at Tso-chen and Hsin-chu indicate possible stratigraphic correlation. --M. Russell.

1-2991. Hiltermann, Heinrich. ANNOTATED BIBLIOGRAPHY OF MICROPALEONTOLOGY IN GERMANY FOR 1958; Micropaleontology, v. 5, no. 4, p. 487-496, Oct. 1959.

One hundred and twenty papers on all aspects of micropaleontology are listed and briefly reviewed. --Auth.

1-2992. Nakkady, S.E. BIOSTRATIGRAPHY OF THE UM ELGHANAYEM SECTION, EGYPT: Micropaleontology, v. 5, no. 4, p. 453-472, 7 pls., chart, Oct. 1959, 33 refs.

The present work is a biostratigraphic study of the Maestrichtian, Danian, and Montian formations [Cretaceous] and their microfaunas in Gabal Um Elghanayem of the western desert of Egypt. The Echinocorys chalk, with a typical Danian macrofauna, is flooded with Globorotalia of the simulatilis-velascoensis group and with other members of the Globorotalia zone microfauna. --Auth.

1-2993. Boltovskoy, Esteban. FORAMINIFERA AS BIOLOGICAL INDICATORS IN THE STUDY OF OCEAN CURRENTS: Micropaleontology, v. 5, no. 4, p. 473-481, 3 pls., map, Oct. 1959, 22 refs.

In the present study Foraminifera are used for the first time to determine the limits of ocean currents. Argentine ocean waters are divided into 3 masses; the planktonic and benthonic Foraminifera that are biological indicators of these masses have been determined, and on this basis the western limit of the Malvin current waters on the northern part of the Argentine shelf has been defined. It is believed that the Malvin waters extend up to latitude 22°S., near Cabo Frio, but do not reach the shores of Brazil, and that they sink, become mixed with waters of other origins, and are distributed only on the sea bottom, being covered by the Brazilian waters. --Auth.

1-2994. Ashworth, Edwin T. OCCURRENCE OF GLOBOTRUNCANA VENTRICOSA IN NORTHWESTERN PERU: Micropaleontology, v. 5, no. 4, p. 497-499, 3 illus., map, Oct. 1959, 12 refs.

Globotruncana ventricosa ventricosa [Foraminifera] is recorded from core samples of Maestrichtian age [Cretaceous] in the Sechura desert of northwestern Peru. Location map and illustrations are included. --Auth.

1-2995. Drooger, C.W., and C. Socin. MIOCENE FORAMINIFERA FROM ROSIGNANO, NORTHERN ITALY: Micropaleontology, v. 5, no. 4, p. 415-426, 2 illus., map, 2 tables, Oct. 1959, 32 refs.

In the region of the classic locality of Rosignano, the highly developed Lepidocyclina (Nephrolepidina) tournoueri is accompanied by Miogypsina (Miogypsina) globulina. The associated planktonics mainly consist of Globoquadrina dehiscens and Globigerina globularis, with scarcer Globigerinoides triloba. The Burdigalian age of this fauna shows the persistence of the Lepidocyclinidae in the Miocene of the Mediterranean area. --Auth.

1-2996. Lindström, Maurits. CONODONTS FROM THE CRUG LIMESTONE (ORDOVICIAN, WALES): Micropaleontology, v. 5, no. 4, p. 427-452, 3 figs., 4 pls., map, Oct. 1959, 42 refs.

The Crug limestone was deposited during an interval in terrigenous sedimentation, hence the rich conodont fauna. The conodonts are comparable with other roughly contemporaneous Welsh faunas and with the

Keisley limestone fauna, which is also, possibly, to some extent Caradocian. Among the fauna described are 6 new species. One asymmetrical Ozarkodina has only "right" specimens. The status of Prioniodina- and Cordylodus-like genera is discussed. --Auth.

1-2997. Lagaaij, R. SOME SPECIES OF BRYOZOA NEW TO THE BOWDEN BEDS, JAMAICA, B.W.I.: Micropaleontology, v. 5, no. 4, p. 482-486, 5 illus., Oct. 1959, 20 refs.

Six bryozoan forms are described from the type locality of the middle Miocene Bowden formation of Jamaica. All are new to the known Bowden assemblage, and one is believed to be a new species. The stratigraphic and geographic distribution of each of these forms is reviewed. --Auth.

1-2998. Echols, Dorothy Jung, and Wilgus B. Creath. SURVEY OF MISSISSIPPIAN, PENNSYLVANIAN, AND PERMIAN OSTRACODA RECORDED IN THE UNITED STATES: Micropaleontology, v. 5, no. 4, p. 389-414, 11 maps, fold. chart, Oct. 1959, 141 refs.

This study represents a survey of United States literature pertaining to ostracods from the Mississippian, Pennsylvanian, and Permian periods. The text consists of a check list of genera and species, recording their occurrences within series. The figures consist of 11 maps of outcrops by series, with locations of areas treated in faunal papers, and 1 range chart of valid genera, on which the number of species within each genus is indicated. --Auth.

1-2999. Terasmae, Jaan, and John G. Fyles. PALAEOBOTANICAL STUDY OF LATE-GLACIAL DEPOSITS FROM VANCOUVER ISLAND, BRITISH COLUMBIA: Can. Jour. Botany, v. 37, no. 5, p. 815-817, 7 illus., table, Sept. 1959, 5 refs.

Plant-bearing beds have been discovered by J.G. Fyles in late-glacial deposits from the Englishman River section, Vancouver Island, B.C. Radiocarbon dating indicated an age of ca. 12,000 years for these beds. Fossil cones of Pinus contorta Dougl. and leaves of Dryas drummondii Richards. were discovered and identified. Palynological study indicates that climate at the time was colder that the present. --Auth.

6. GEOPHYSICS

See also: Areal and Regional Geology 1-2945; Structural Geology 1-2966, 1-2967, 1-2969; Sedimentary Petrology 1-3120; Fuels 1-3156; Engineering Geology 1-3168, 1-3170, 1-3173, 1-3181, 1-3185.

1-3000. Hall, H. Tracy. ULTRAHIGH PRESSURES: Sci. American, v. 201, no. 5, p. 61-67, 6 illus., chart, Nov. 1959.

Laboratory apparatus is now capable of maintaining steady pressures of as much as 200,000 atmospheres, equivalent to the pressure 400 mi. beneath the earth's surface. The tetrahedral-anvil pressure apparatus consists of 4 high-pressure cylinders arranged symmetrically around a central point. Combined high-pressure and high-temperature experiments have succeeded in attaining pressure of 130,000 atmospheres at 3,000°C., making it possible to simulate conditions under which many rock-forming minerals crystallize. --M. Russell.

1-3001. Caputo, Michele. CONFORMAL PROJECTION OF AN ELLIPSOID OF REVOLUTION WHEN THE SCALE FACTOR AND ITS NORMAL DERIVATIVE ARE ASSIGNED ON A GEODESIC LINE OF THE ELLIPSOID: Jour. Geophys. Research, v. 64, no. 11, p. 1867-1873, table, Nov. 1959, 5 refs.; also pub. as; California, Univ. (Los Angeles), Inst. Geophysics, Pub. no. 142.

In this paper a method of finding the scale factor and the correspondence equations of the conformal projection of an ellipsoid of revolution on a plane is given in the case where the scale factor and its normal derivative are assigned on a geodesic line of the ellipsoid. In particular the method is applied to the case for which the scale factor is constant and has zero normal derivative on that line.

This method is based on the a priori determination of the scale factor, by means of the Souslow-Marussi equation, and by the use of it in the solution of the partial differential equations of the projection. --Auth.

1-3002. Popov, E.I. NEW EXPERIMENTAL DATA CONCERNING THE CREEP OF THE ZERO POINT OF QUARTZ GRAVIMETERS, BASED ON THE USE OF THE TWISTED FIBERS: Akad. Nauk SSSR, Bull, Geophysics Ser., in translation, 1958, no. 5, p. 371-377, 2 illus., 5 graphs, 7 tables, pub. Sept. 1959.

The elastic properties of torsion fibers made of different kinds of quartz glass and used in the elastic systems of the Norgaard and the Russian CH-3 gravimeters were investigated, in order to find the best material and optimum conditions for decreasing the drift of the zero point of these instruments. It is concluded that under constant external conditions the zero-point drift of the quartz system is determined by creep of the quartz fibers and the resulting elastic aftereffect. The duration of a high rate of creep can be reduced to 5 to 10 days, instead of 80 to 100 days, by first twisting the threads over a greater angle and holding them in this state for a short while, then heating to a temperature of 186° to 200°C. The reduction of the rate of final creep of the zero point can be attained by increasing the thickness of the fiber and adjusting the thermostatic temperature to about 0°C.

Neither the kind of quartz nor the variation of the stress on the threads from 4 to 30% of their strength affect the rate of final creep. The same result was obtained by the use of tubular threads. The decrease of the diameter of the thread to about 30 to 40 μ causes a sharp increase of the creep. The change from pure quartz glass to one with different materials added increased the creep in all trials. --S. T. Vesselowsky (courtesy Geophysical Abstracts 174-198).

1-3003. Harrison, J.C. TESTS OF THE LaCOSTE-ROMBERG SURFACE-SHIP GRAVITY METER I: Jour. Geophys. Research, v. 64, no. 11, p. 1875-1881, 5 maps, 2 profiles, table, Nov. 1959, 2 refs.; also pub. as; California, Univ. (Los Angeles), Inst. Geophysics, Pub. no. 147.

Gravity measurements made with a LaCoste-Romberg surface-ship gravity meter on board the

M. V. Horizon along a 300 mi. track off southern California are compared with submarine measurements near the track. The agreement ($\pm$ 5 mgal.) is considered to be as close as can be expected from this type of comparison. --Auth.

1-3004. Kuzivanov, V.A. DETERMINATION OF THE FORCE OF GRAVITY BY A GRAVIMETER AT SEA: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 5, p. 367-370, 2 figs., pub. Sept. 1959, 3 refs.

The main difficulty in the determination of gravity at sea by means of gravimeters is the necessity of taking into account the movement of the support of the gravimeter, which can be vertical, horizontal, or rotational accelerations due to displacements, as well as inclinations on the moving ship. Analyzing the differential equation of the moving support, Kuzivanov recommends using a gravimeter with overdamped system and adjusting the pendulums almost horizontally. This decreases the effect of disturbing terms in the differential equation of the motion, making it possible to neglect many of them. A further decrease of the disturbing effect can be attained by the use of 2 pendulums mounted in opposite directions. The readings of these pendulums must be corrected for the effect of the angles of inclination of the base and of horizontal accelerations, which must be recorded by special vertical and horizontal accelerometers. --S. T. Vesselowsky (courtesy Geophysical Abstracts 174-194).

1-3005. Romanyuk, V.A. DETERMINATION OF THE GRAVITY FORCE AT SEA BY THE PENDULUM METHOD III: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 1, p. 29-33, fig., 4 tables, pub. 1959, 3 refs.

The approximate differential equations are given for motion of inclinometers and accelerometers, taking into account the second order terms. The allowable errors in measuring the magnitude of components of acceleration and inclinations of support are determined. The approximate solutions of differential equations of the motion of inclinometers and accelerometers are obtained. The expression for $[\ddot{U}_o^2]$, $[\ddot{V}_o^2]$, and $[\ddot{W}_o^2]$ are derived; practical examples of their calculation are examined, as well as corrections of second order for points, determined on surface ships. --Auth.

1-3006. Malovichko, A.K. ON THE DETERMINATION OF THE DEPTH OF A BODY ACCORDING TO GRAVITATIONAL AND MAGNETIC ANOMALIES: Prepared by U.S. Joint Publications Research Service: Internat. Geology Rev., v. 1, no. 9, p. 39-41, illus., graph, Sept. 1959, 3 refs.

A 2-dimensional formula using gravitational and/or magnetic observations of both the unmapped body and an exposed anomalous object located at the same depth along a line of common extension is devised to decrease error in determining the depth of an anomalous deposit. Practically, the same effect can be achieved by simply adding to an anomalous field with insufficient extension isoanomalies of identical fields on either side. --G. E. Denegar.

1-3007. Hall, Donald H. DIRECTION OF POLARIZATION DETERMINED FROM MAGNETIC ANOMALIES: Jour. Geophys. Research, v. 64, no. 11, p. 1945-1959, 3 secs., 2 profiles, 4 diags., 5 graphs, 2 tables, Nov. 1959, 10 refs.

In traditional methods of interpretation of the results of magnetic surveys the effects due to permanent magnetization are neglected. Recent geomagnetic research on the remanent magnetization of rocks has shown this neglect to be unjustified. Moreover, techniques now being employed provide better measurements of magnetic-field variations than have ordinarily been available in the past. With most of the newer methods components of the field are measured in directions other than those generally treated in the earlier methods of interpretation. In order to take advantage of the new developments, equations for the magnetic field over a point dipole, a horizontal line of dipoles, a thin, dipping sheet, a thick, dipping sheet, and a sloping step are derived in the case when both the directions of measurement and polarization are arbitrary.

It is found that these directions combine with other properties of the bodies to form parameters from which various features of the magnetic anomalies over the bodies can be determined. In terms of these combined parameters it is possible to obtain the higher derivatives of the expressions for the fields over these bodies and to develop methods of determining the unknown parameters of the bodies, including the direction of polarization, when magnetic profiles over them are given. Further, it is shown that the fields over 4 of the bodies treated can be obtained by successive differentiation of a single function. This fact is used in drawing charts for computing values of the fields and their derivatives at points along profiles over any of these bodies. Graphs are given, showing the position of special points such as peaks and inflection points on the profiles for any direction of polarization and measurement.

Methods of calculation of the unknown parameters of the line of dipoles and the thin, dipping sheet when their anomalies are given, are outlined, followed by examples of calculation in the case of theoretically calculated sample profiles. --Auth.

1-3008. Hargraves, Robert B. MAGNETIC ANISOTROPY AND REMANENT MAGNETISM IN HEMO-ILMENITE FROM ORE DEPOSITS AT ALLARD LAKE, QUEBEC: Jour. Geophys. Research, v. 64, no. 10, p. 1565-1578, 6 illus., sec., 5 diags., graph, 5 tables, Oct. 1959, 15 refs.

The anisotropism of magnetic susceptibility of nearly pure hemo-ilmenite ore from deposits in the Allard Lake area consists of a distinct plane of maximum susceptibility (defined by maximum and intermediate axes along which the susceptibility is of similar magnitude) with a minimum susceptibility axis at right angles. This plane coincides with a preferred crystallographic grain-orientation indicated by the parallelism of titanhematite lamellae which have exsolved on the basal plane of the ferrianilmenite host grains. Measurement of the remanent magnetism (RM) shows a striking tendency for the RM vectors to lie in or near this preferred plane. On the assumption that hematite (if not ilmenite as well) is potentially ferromagnetic in the basal plane only (paramagnetic parallel to the c-axis), it was inferred that the RM vectors could represent the resolved component of the magnetizing field which tended to lie in the plane of maximum susceptibility. Under this hypothesis, it is possible to resolve the broad spread shown by the RM vectors of samples from one deposit in terms of a single magnetizing field direction. The variation of the intensity of RM of otherwise similar samples can also be explained on this basis.

With one exception, the RM of 47 measured samples of hemo-ilmenite ore was reversely polarized (N-seeking pole up). Additional "natural history" evidence bearing on the problem of self-reversal of thermo-remanent magnetism (TRM) is provided by this study. --Auth.

1-3009. Kalashnikov, A.G. THE DISTRIBUTION OF REMANENT MAGNETIZATION IN CUBES AND CYLINDERS OF ROCKS: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 4, p. 308-310, 10 figs. incl. illus., diags., graphs, pub. Aug. 1959, ref.

Cubic and cylindrical samples were made of clay with the addition of 57% (by volume) of powdered magnetite. The susceptibility of this mixture was about 0.12. The cubes were 7 cm. on edge; the radii of the cylinders 4 cm., their height 6 cm. These specimens were magnetized in a homogeneous magnetic field having a constant intensity of 150 oersteds. The direction of the edges of the cubes and of the axes of the cylinders coincided with the direction of the magnetizing field. The specimens were cut into cubes 9 mm. on edge and the remanent magnetism of these small cubes investigated. It was found that only the specimens taken from the center portion of the initial specimens preserved the direction of the initial magnetizing field; all the others showed deviations up to 15°. This fact must be kept in mind in paleomagnetic studies. --S. T. Vesselowsky (courtesy Geophysical Abstracts 173-287).

1-3010. Marshall, Donald J., and Theodore R.M. Madden. INDUCED POLARIZATION, A STUDY OF ITS CAUSES: Geophysics, v. 24, no. 4, p. 790-816, 16 figs. incl. diags., graphs, 7 tables, Oct. 1959, 22 refs.

The causes of induced electrical polarization include not only the polarization of metal-solution interfaces, but also effects associated with the coupling of different flows. Electro-osmotic, thermal electric, and ion diffusion effects are among such examples. A study of the physical properties of geologic materials indicates that only electrode interface and diffusion flow phenomena are important sources of induced polarization effects.

It was attempted to find characteristic differences between these 2 phenomena. Theoretical and experimental considerations show that the kinetic processes involved are quite similar in the 2 cases. This leads to difficulties in identifying the polarizing agent from electrical measurements, although the effects of well mineralized zones are easily recognized. --Auth.

1-3011. Ward, Stanley H. AFMAG - AIRBORNE AND GROUND: Geophysics, v. 24, no. 4, p. 761-789, 19 figs. incl. 4 maps, diags., graphs, Oct. 1959, 12 refs.

The existence of natural magnetic fields in the audio and subaudio frequency range has been known for some time. The primary source of energy for these fields is usually considered to be distant and local thunderstorms. Because of this origin, the fields are quasi-random, with both amplitudes and directions changing drastically over short periods of time. Hence, use of these fields in geophysical prospecting has been extremely limited.

A new development, AFMAG, however, essentially eliminates the time variance in recording these fields without any sacrifice of the intelligence of their space variance. Since the space variance can be correlated with geologic features, AFMAG provides a new method of exploration, with particular application to prospecting for conductive mineral deposits.

Instrumentation of the AFMAG method currently is available for both ground and airborne operation; the tilt of the plane of polarization of the natural magnetic fields is recorded simultaneously at 2 frequencies. Examples drawn from airborne and ground surveys show that the method has a much greater depth of exploration than its conventional cousin, the induction electromagnetic method. Numerous other advantages, such as the possibility of choosing discrete operating frequencies over a broad band from 1 c. p. s. to 1,000 c. p. s., are discussed. The chief disadvantage of the method lies in a sometimes restricted daily measuring period during which the fields are of an amplitude too low to permit measurement with current instrumentation. This is not a serious problem and is being minimized as the technology improves. --Auth.

1-3012. Khmelevskoi, V.K., and A.D. Frolov. MEASUREMENTS OF THE INTENSITIES OF THE RADIO-WAVE FIELD OF BROADCAST STATIONS FOR GEOLOGIC MAPPING. Prepared by U.S. Joint Publications Research Service: Internat. Geology Rev., v. 1, no. 9, p. 33-38, 4 secs., 5 graphs, Sept. 1959.

Comparison of measurements of radio frequency fields determined by means of a received signal and a signal from a standard generator can be used to separate steeply descending and inclined layered deposits possessing variable electrical properties. No specially developed apparatus is required for this type of geophysical prospecting, nor is time of measurement an essential variable factor in interpretation of comparisons. By simple calculations, it is easy to obtain the form of various irregularities in lithology, structure, and mineralization, Because the anomalies in the radio frequency field are of a narrow local character, the radio-comparison method is primarily effective for detailed prospecting. --G. E. Denegar.

1-3013. Gilbert, Ray E. NOTES ON GEOPHYSICAL WORK AT MARYSVALE, UTAH: U.S. Atomic Energy Comm., [Pub.] RME-2050, 24 p., 13 figs. incl. maps, cross secs., May 1958, 2 refs.

The Marysvale area lies in S.-central Utah, 175 mi. S. of Salt Lake City. U deposits of the area are in volcanic and plutonic rocks of Tertiary age. Direct current resistivity methods were tested in 2 localities in the Marysvale area. In the Bullion Monarch mine area, an altered rhyolite dike was successfully traced by this method, and the information was used in planning diamond drilling for U occurrences within the dike. In the Lucky Strike area, an attempt was made to locate the contact between the quartz monzonite and rhyolite agglomerate and to measure the thickness of the rhyolite. Subsequent diamond drilling proved the contact to be about 200 ft. farther E. and 100 ft. deeper than was predicted from the resistivity work. The error may have been caused by a lack of homogeneity in the basal section of the rhyolite. Self-potential and resistivity methods were tested across the Prospector vein. Neither method detected the vein.

Resistivity methods can be used to outline zones of intense alteration, thereby supplying desirable information on the location of U deposits in altered rhyolite. Magnetometer traverses could be run along the old resistivity lines to ascertain if comparable results may be obtained. --Auth.

1-3014. Enenshtein, B.S., and E.V. Rybakova. SOME RESULTS OF ELECTROMAGNETIC SOUNDING OF GEOLOGICAL STRUCTURES: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 1, p. 81-82, 2 graphs, pub. 1959, ref.

This paper presents the results of electromagnetic sounding of a geologic structure screened by intermediate nonconducting strata, in an unidentified area of the U. S. S. R. The geologic structure, established from the data of electric logging and vertical electric profiling near the drill hole, is as follows: 500 m. of clays, sandstones, and marls of Cambrian, Silurian, and Devonian age with resistivities ranging from 3 to 6 ohm-m., rest on the Precambrian basement; these are overlain by some 100 m. of Permian anhydrite of practically infinite electric resistivity; above these lies a Triassic formation about 100 to 110 m. thick with a specific resistivity of about 50 ohm-m., and above this 130 m. of argillaceous sands with a resistivity of 70 to 80 ohm-m. The field survey was made by the method of "equatorial electromagnetic frequency soundings." The results are presented in 2 curves. Analysis of these curves on the basis of the considerations explained in a previous article, shows sufficiently good agreement with the results obtained earlier and indicated above. --S. T. Vesselowsky (courtesy Geophysical Abstracts 175-118).

1-3015. Beckmann, Walter C., Archie C. Roberts, and Bernard Luskin. SUB-BOTTOM DEPTH RECORDER: Geophysics, v. 24, no. 4, p. 749-760, 8 figs. incl. illus., diags., Oct. 1959, 11 refs.; also pub. as; Columbia Univ., Lamont Geol. Observatory, Contr. no. 361.

The Sub-bottom Depth Recorder (SDR) has been developed to study the underlying geologic structure of water-covered areas. The SDR is essentially a broad-band, high-powered echo sounder which utilizes 1 of 2 sound sources.

The first, an electrical spark discharge (Sparker), has produced penetrations in excess of 600 ft. in 50 ft. of water. The second, a combustion chamber using a mixture of propane and oxygen (RASS), has produced penetrations in excess of 1,400 ft. in 80 ft. of water.

Results obtained from the SDR have been found to be in excellent agreement with test boring and seismic refraction data. --Auth.

1-3016. Grannemann, W.W. FIELD TESTING SEISMIC INSTRUMENTS: Geophysics, v. 24, no. 4, p. 817-822, Oct. 1959.

The field tests compiled here are designed to detect the presence of the subtle as well as the obvious equipment troubles. Auxiliary test equipment used includes a low distortion sine wave oscillator, oscilloscope, geophone shaketable, and a timing standard, as well as the usual voltmeter, ammeters, and ohmmeters which are often built in the equipment. Field test procedures on geophones, cables, seismic amplifier, seismic oscilloscope cameras, magnetic seismic recorders are included. The time lapse between each test is considered, but some flexibility in this respect is recognized, depending on the specific equipment used and the operating conditions. --Auth.

1-3017. Pasechnik, I.P., and N.E. Fedoseenko. AN ELECTRODYNAMIC MICROBAROGRAPH WITH RECORDING GALVANOMETER: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 1, p. 71-75, 8 figs. incl. 3 diags., pub. 1959, 15 refs.

Microfluctuations of atmospheric pressure influence the level of the background of microseisms, posing a limit to the sensitivity of seismic receivers. This effect is especially noticeable in deep seismic surveying. Also of interest is the question of the cause of the acoustic waves which often accompany earthquakes. This paper describes the construction and operation of microbarographs designed by Pasechnik and Fedoseenko. Two slightly different models of the instrument were built. The principal element of the one is a hermetically sealed chamber 28,000 cm.^{3} in volume with one side made of a thin (0.1 mm. bronze membrane. The displacement of the middle point of this membrane is measured by an electrodynamic transducer and recorder by the usual means. The second, similar to those used by Gutenberg and Benioff and others in different countries, is lighter and better adapted to field use.

Tests have proved the efficiency of both instruments for use in seismic stations and in the field. Numerous observations of barometric microfluctuations are discussed. Both instruments are well suited for use in the investigations of the causes and origin of microseisms. --S. T. Vesselowsky (courtesy Geophysical Abstracts 176-290).

1-3018. Popov, I.I. A SHORT-PERIOD VERTICAL MAGNETIC RECOVERY FORCE SEISMOGRAPH: Akad. Nauk. SSSR, Bull., Geophysics Ser., in translation, 1958, no. 6, p. 445-447, 3 illus., 2 diags., 2 graphs, pub. Oct. 1959, 4 refs.

A description is given of a new type of short-period vertical seismograph with a magnetic restoring force. A magnetized mass m moves on a vertical guide line under the action of gravity and the force exercised by the magnet M placed slightly off the line of motion of the mass m. The vertical component of the restoring force $f_1 = \underline{B} \sin^2 \phi \cos \phi$, where B is a constant of the instrument and ϕ is the angle between direction of the restoring force and the vertical. This restoring force increases from the equilibrium point to a maximum, then decreases and even changes its sign. This stops the operation of the seismograph. For sufficiently small amplitudes of vibration it operates with great amplification. The degree of damping and the amplification of the seismograph can be varied over a wide range.

An experimental model of this seismograph was built and tested on the shaking table of the seismometric laboratory of the Institute of the Physics of the Earth; it proved to be a reliable and sturdy instrument, especially suitable for strong earthquakes. --S. T. Vesselowsky (courtesy Geophysical Abstracts 175-63).

1-3019. Kolosenko, M.N. ACCOUNTING FOR THE ELLIPTICITY OF THE EARTH WHILE DETERMINING THE EPICENTRAL DISTANCES: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 1, p. 67-70, 2 figs., 4 tables, pub. 1959, 8 refs.

The ellipticity of the earth affects the travel time of seismic waves, for this time interval is determined not only by the epicentral distance from the station, but also by the relative position of the epicenter and the station on the terrestrial ellipsoid. For the sake of uniformity the observations made at different points are usually referred to a conventional sphere of the same volume as the terrestrial ellipsoid. This permits the use of the Jeffreys-Bullen tables. It is necessary in this case to use the geocentric coordinates φ^1 and λ^1, related to the geographic coordinates φ and λ by the equations: $\lambda^1 = \lambda$, $\tan \varphi^1 = (1 - \alpha^2) \tan \varphi$, where α is the flattening of the ellipsoid. If the geographic coordinates are used, an error is introduced which in the case of the epicenters situated in North America can be as high as 0.4° for the Soviet seismic stations.

The procedure is given for evaluating the correction for different positions of the epicenter and for different points of observation. A table is included, giving for each of the 75 Russian stations its geographic and geocentric latitude and longitude, as well as the geocentric direction cosines and the value of the radius of curvature for different latitudes. Finally the length of 1° on the earth's surface is given in lateral and meridional directions at different points. --S. T. Vesselowsky (courtesy Geophysical Abstracts 175-44).

1-3020. Gutenberg, B. EARTHQUAKE WAVES REFLECTED AT THE INSIDE OF THE CORE BOUNDARY: Jour. Geophys. Research, v. 64, no. 10, p. 1503-1508, 3 graphs, 3 logs, table, Oct. 1959, 11 refs.; also pub. as; California Inst. Technology, Div. Geol. Sci., Contr. no. 933.

Travel times of waves generated by an earthquake at a depth of 600 km. and reflected from the inside of the core boundary as well as the epicentral distances of the caustics of PKKP, SKKP, and PKKS agree within the limits of error with those calculated on the basis of velocity-depth curves. This applies also to the travel times of SKKS and SKKKS for which poor agreement was reported before the inner core was established. The periods of all waves traveling through the outer core seem to be shortened. In the outer core the attenuation is possibly smaller than in the mantle. --Auth.

1-3021. Riznichenko, Yu. V. THE MASS DETERMINATION OF THE COORDINATES OF LOCAL EARTHQUAKES AND OF THE VELOCITIES OF SEISMIC WAVES IN THE SOURCE AREAS: Akad. Nauk. SSSR, Bull., Geophysics Ser., in translation, 1958, no. 4, p. 243-248, 6 figs., pub. Aug. 1959, 29 refs.

The author suggests the plotting of isochrones as a method for determining the coordinates of local earthquakes, and the use of theoretical travel time curves of direct (or penetrating refracted) waves to determine the focus. Both methods are based on the comparison of observed arrival times with precalculated theoretical travel time curves. For determining average velocities and velocities in layers as functions of the observed depths of a series of earthquakes, the use of vertical travel time curves [is suggested]. All 3 methods are based on the assumptions and procedures applied in seismic prospecting. --Auth.

1-3022. Treskov, A.A. DIFFERENTIAL METHOD OF DETERMINING THE DEPTH OF FOCUS OF A NEAR EARTHQUAKE: Akad. Nauk. SSSR, Bull., Geophysics Ser., in translation, 1958, no. 4, p. 304-307, pub. Aug. 1959.

Treskov suggests a new procedure for determination of the depth of focus of an earthquake. As the travel-time curves of the waves propagating through a homogeneous ground are hyperbolic, it is possible to find the depth of focus given the seismic velocity of a certain region and the time records of a single station. It is recommended that 6 to 9 stations be taken to construct the travel-time curve best fitting the observational data. This is done by the methods of observational calculus. The epicentral distances of the earthquakes selected can range from 30 to 100 km. The mathematical computations are presented in detail for an actual example. Accuracy of the results of the calculations is satisfactory. --S. T. Vesselowsky (courtesy Geophysical Abstracts 173-55).

1-3023. Puchkov, S.V. FUNDAMENTALS OF A COMPLEX METHOD OF SEISMIC ZONING: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 1, p. 61-65, map, sec., 4 graphs, pub. 1959, 11 refs.

Certain points to be taken into consideration in the new edition of the seismic atlas of the U. S. S. R. are discussed. Earthquakes result either from the displacement of tectonic structures along slippage planes, or from the rupture of the structure under stresses exceeding the limit of resistance of the rock material. These faults may appear on the terrestrial crust under a thick layer of friable argillaceous sandstones. It is important to distinguish those which are "active," that is, capable of producing new displacements in successive earthquakes. Buried ruptures can be located by instrumental surveying. The force manifested during the rupture is determined by the area and mechanical resistance of the rock at the depth of the focus of the earthquake. The limiting intensity of earthquakes on basic rocks cannot exceed 7 to 8 for focal depths of 10 to 30 km. The initial waves consume only 2 to 3 x 10^{-3} of the total energy of the shock, but the intensity of waves emanating from the focus can increase, due to resonance phenomena in the upper formations. Thus earthquakes on friable formations can be 2 grades higher than on basic rocks. Puchkov also points to the fact that the greatest amplitude of the waves and consequently of the intensity of the earthquake may not be found at the focus but at some distance from it. --S. T. Vesselowsky (courtesy Geophysical Abstracts 175-45).

1-3024. Tocher, Don, and Jack Cameron. EARTHQUAKES IN NORTHERN CALIFORNIA, NEVADA, AND OREGON, AND REGISTRATION OF EARTHQUAKES AT: BERKELEY, MOUNT HAMILTON, PALO ALTO, SAN FRANCISCO, FERNDALE, FRESNO, MINERAL, ARCATA, RENO, CORVALLIS, SHASTA, AND MANZANITA LAKE, FROM JULY 1, 1957 TO SEPTEMBER 30, 1957: California, Univ., Bull. Seismog. Sta., v. 27, no. 3, p. 139-190, map, tables, 1959.

1-3025. Scheidegger, Adrian E. NOTE ON THE TECTONICS OF KERN COUNTY, CALIFORNIA, AS EVIDENCED BY THE 1952 EARTHQUAKES: Jour. Geophys. Research, v. 64, no. 10, p. 1499-1501, 2 maps, Oct. 1959, 5 refs.; also pub. as: California Inst. Technology, Div. Geol. Sci., Contr. no. 928.

A statistical analysis has been made of the mechanisms of the aftershocks of the Kern County earthquake of July 21, 1952. A method the writer developed earlier shows the direction of tectonic motion to be at N. 32°W, approximately normal to the strike of the White Wolf fault. This is in agreement with Gutenberg's fault-plane solution for the main Kern County earthquake which yielded an overthrust in a northwesterly direction. It therefore appears that the Kern County earthquake and its aftershocks were caused by the same tectonic effects.--Auth.

1-3026. F.V. HAYDEN'S EARTHQUAKE CAMP, 1872: GeoTimes, v. 4, no. 4, p. 11, illus., Nov.-Dec. 1959, 2 refs.

One of the earliest records of intensive earthquake activity in the same general area as the recent Hebgen Lake earthquake can be found in reports by F. V. Hayden, 1872, and W. H. Jackson, 1874, describing a severe earthquake on Aug. 19-20, 1871. Earthquake Camp, near Steamboat Point, on the E. side of Yellowstone Lake, Wyoming, was so named because this was the site where Hayden's party experienced the Aug. 1871 tremors. --M. Russell.

1-3027. Rezanov, I.A. THE ASHKHABAD EARTHQUAKE OF 1948 AND ITS GEOLOGICAL BACKGROUND: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 6, p. 407-413, 9 figs. incl. 3 maps, 3 diags., graph, profile, pub. Oct. 1959, 31 refs.

The epicenter of the Ashkhabad [Turkmenian S. S. R.] earthquake of 1948 was the line between the points at 38°03'N., 58°31'E. and 37°75'N., 58°65'E., forming the major axis of the oval formed by the grade 9 isoseismal line. The earthquake was related to recent tectonic uplift of the southwestern portion of the Kopet-Dag depression. Judging from the depth of the aftershocks, the fracture involves the Paleozoic basement down to about 10 to 12 km. The earthquake records and the data of a precise leveling made after the earthquake show that the southwestern side of the fracture moved upward and the northeastern side downward. The location of the aftershocks at either end of the epicentral axis confirms the linearity of the focus and proves that the initial assumption of the existence of 2 distinct epicenters of this earthquake was erroneous. --S. T. Vesselowsky (courtesy Geophysical Abstracts 175-32).

1-3028. Solovev, S.L. THE NORTH BAIKAL EARTHQUAKE OF APRIL 29, 1917: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 4, p. 299-303, illus., 2 maps, 7 tables, pub. Aug. 1959, 24 refs.

The region around the Baikal lake is characterized by high seismicity; during the period 1862 to 1950, 13 earthquakes occurred with intensities ranging from 7 to 10 on the Modified Mercalli scale. Due to sparseness of population and the absence of seismic stations the region is insufficiently known seismologically, a lack which is now felt in the rapid industrialization of the area. The earthquake of Apr. 29, 1917, has been studied, using the records of 4 Russian (Pulkovo, Irkutsk, Sverdlovsk, and Tbilisi), 6 Italian, and 4 Japanese stations. The coordinates of the epicenter, the magnitude, and the depth of focus are found to be $\phi=55^{\circ}$ to 56°N.; $\lambda=115^{\circ}$ to 116°E., M= 6 1/4 ± 1/4, and h=25-30 km., respectively. --S. T. Vesselowsky (courtesy Geophysical Abstracts 173-48).

1-3029. Tamrazyan, G.P. ON THE SEISMIC ACTIVITY OF THE NORTHWEST BORDER AREA OF THE PACIFIC OCEAN: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 5, p. 378-381, 3 figs., 4 tables, pub. Sept. 1959, 7 refs.

Data obtained by Russian seismic stations in the period 1909-1944 on some 240 earthquakes which occurred in the zone extending along the western border of the Pacific Ocean from the Aleutian Islands the Kamchatka peninsula, the Kurile Islands, Japan, the Philippine Islands, New Guinea, and the Solomon Islands to western Indonesia are analyzed statisticall The foci of these earthquakes ranged from 50 to 800 km. in depth. As in his previous studies Tamrazyan investigated the relationship between the occurrence of earthquakes and different cosmic factors, especially phases of the moon. The earthquakes are classifie according to the phase of the moon during which they occurred; at least 40% more occurred during the new and full moon than during the rest of the lunar month, or considering only the earthquakes with focal depths of 80 to 350 km., about 66% more. --S. T. Vesselowsky (courtesy Geophysical Abstracts 174-34).

1-3030. De Bremaecker, J. Cl. SEISMICITY OF THE WEST AFRICAN RIFT VALLEY: Jour. Geophys. Research, v. 64, no. 11, p. 1961-1966, 3 maps, diag., 2 tables, Nov. 1959, 20 refs.

All the epicenters determined in the central part of the West African rift valley up to the middle of 1958 have been plotted on a map. Most of them are on the faults which border the rift; a few are on faults which crosscut it. The eastern Virunga "extinct" volcanoes show a farily strong seismic activity. The most important discovery is that of a transverse zone stretching W. from Lake Kivu to the Congo river (450 km.); extinct or active volcanoes are located at the intersection of this zone with the rift valley.

Diagrams show the amount of seismic energy liberated per year within 500 km. of Lwiro. The mean value is 3.5 x 10^{20} ergs/year, which is about 0.03% of that of the earth as a whole. --Auth.

1-3031. Savarensky, E.F. SEISMOLOGY IN THE CHINESE PEOPLE'S REPUBLIC: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 6, p. 433-436, illus., map, pub. Oct. 1959, 4 refs.

This is a brief report on the trip made by Savarensky, as chairman of the council on seismology of the Russian Academy of Sciences, to China in 1957-1958. From a map given it can be seen that over half the territory of China is seismically active. The central and western portions of China are subject to violent earthquakes, for example, the earthquake of Hansu on Dec. 16, 1920, one of the most violent earthquakes of the entire globe. China is only little less dangerous seismically than Japan, the most dangerous region being in eastern Tibet. Here near the boundary between India and China an earthquake of magnitude 8.6 occurred on Aug. 15, 1950.

The foci of most of the earthquakes are located within the earth's crust. At present China has 25 seismic stations. All the equipment of these stations is built in China, although most of the instruments are of foreign design. Two tripartite seismic stations one in Shanghai, another in Canton, are built for the study of microseisms.

Along with the industrial development of the country, much attention is being given to engineering seismology and to the development of earthquake-resistant industrial construction. The article ends with the description of several seismic stations in different parts of China. --S. T. Vesselowsky (courtesy Geophysical Abstracts 175-25).

1-3032. Carder, Dean S., and W.K. Cloud. SURFACE MOTION FROM LARGE UNDERGROUND EXPLOSIONS: Jour. Geophys. Research, v. 64, no. 10, p. 1471-1487, 2 maps, 2 charts, sec., 12 graphs, 7 tables, Oct. 1959, 7 refs.

Seismic effects of several underground nuclear explosions were measured in terms of ground surface motion by suitable seismographs from 1,200 ft. to nearly 10 mi. from the source and with teleseismic instruments at great distances. Prior to the Rainier explosion (a 1.7-kt. nuclear shot detonated 900 ft. underground) empirical formulas were developed which predicted ground effects from the Rainier shot and several of the larger Hardtack II shots with fair accuracy but with certain limitations. The limitations were 1) that at distances greater than a few thousand feet, observed displacements were somewhat larger than the formula predicted, necessitating revision of the formula; 2) that frequencies of ground waves did not exceed 20 c. p. s.; and 3) that the source conditions and material were in fair duplication. Ground amplitudes on deep alluvium were, as expected, more than twice the amplitudes at nearly the same distance on rock. Velocity response spectrums of one of the shots have been made and reproduced. The magnitude of the Rainier shot was about 4.0, based on the assumption that the source was contained in a volume of rock comparable to that of an earthquake having the same magnitude. Local travel-time data indicate that the subbasement rock associated with a speed of about 6.2 km./sec. is about 3,600 ft. beneath the shot points area. --Auth.

1-3033. Romney, Carl. AMPLITUDES OF SEISMIC BODY WAVES FROM UNDERGROUND NUCLEAR EXPLOSIONS: Jour. Geophys. Research, v. 64, no. 10, p. 1489-1498, map, 3 graphs, seismogram, 4 tables, Oct. 1959, 17 refs.

Seismic waves from underground nuclear explosions in Nevada were observed at a number of temporary stations along a line extending eastward to Maine. A study of the seismograms from these stations and from a large number of permanent stations has shown that the amplitude of Pn varies inversely as the cube of the distance between 200 and 1,100 km. Pn then disappears and a late-arriving higher velocity wave appears with relatively large amplitude. This later P wave has a slight amplitude maximum at about 2,000 km., after which it decreases irregularly with distance.

Between 200 and 2,000 km. the amplitude of S (or Lg) varies inversely as the cube of the distance. The vertical, radial, and transverse components are of approximately equal size, and are about 3 times the amplitude of Pn between 200 and 1,000 km.

At distances of 100 km. or more the amplitudes of the body waves are proportional to the first power of the explosive yield. The explosions produced seismic waves equivalent in size to those from natural earthquakes of magnitude: $\underline{M} = 3.65 + \log \underline{Y}$, where $\underline{Y}$ is the energy of the explosion expressed in kilotons of TNT equivalent. --Auth.

1-3034. Melamud, A. Ya. TRANSIENT PROCESSES IN SEISMIC PROSPECTING APPARATUS: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 4, p. 267-274, 10 figs. incl. diags., graphs, *pub.* Aug. 1959, 19 refs.

On the basis of an idealized resonance receiving system and an idealized seismic pulse, the operating characteristics of a seismic prospecting receiving apparatus were examined. It is demonstrated that on receiving the seismic waves, the seismic prospecting apparatus functions under what is known as a pulsed (dynamic) regime, when the sensitivity, resolving power, and filtering power depend on the duration of the signal (width of spectrum) at entry. The extent to which the frequency characteristics of the apparatus can be used for determining these parameters in a stationary regime has been determined. --Auth.

1-3035. Isaev, V.S. CONTRIBUTION TO A THEORY OF THE DIRECTIONAL EFFECT OF GROUPS OF SEISMOGRAPHS IN A CASE OF PULSE VIBRATIONS. I: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 6, p. 437-444, 6 figs. incl. 2 graphs, *pub.* Oct. 1959, 15 refs.

An analysis of the effect of a group of seismographs on the direction of recorded waves as well as the distortion of their dynamic characteristics due to the same cause. Earlier work has shown that in the case of steady harmonic vibrations only the amplitude of the final wave is changed, the shape of the waves and frequency of the vibrations remaining unchanged.

In this paper a mathematical analysis of the problem is presented for one impulse and for a sequence of impulses, each in the form of a section of a sinusoidal curve. It is shown that not only the amplitude but also the shape of the wave changes. It is important to note that these changes are not essential in the case when $\Delta\tau/T$ is small (T=duration of the impulse, $\Delta\tau$=phase difference of the impulse wave with respect to the fundamental wave).

For the suppression of disturbing waves produced by impulses it is necessary to select an appropriate phase difference between individual seismographs. This distance may be determined on the basis of the theory developed for geophone grounding in the case of steady harmonic vibrations, but this is not the most suitable method for all cases. --S. T. Vesselowsky (courtesy Geophysical Abstracts 175-353).

1-3036. Acheson, C. Harold. THE CORRECTION OF SEISMIC TIME MAPS FOR LATERAL VARIATION IN VELOCITY BENEATH THE LOW VELOCITY LAYER: Geophysics, v. 24, no. 4, p. 706-724, 20 figs. incl. 4 maps, diags., graphs, 7 tables, Oct. 1959, 20 refs.

Lateral variation in velocity beneath the low velocity layer often causes time anomalies that obscure the true structural picture. A method of correction to a deep datum has been developed to minimize the spurious anomalies without affecting those caused by structure. This method makes use of the discovery that for any particular well in western Canada there exists a simple exponential relationship between time and depth so that the results of relatively shallow core hole velocity surveys can often be extrapolated to predict times to much greater depths. An example is given to show how this method was applied successfully to a particular problem area in western Canada. It has since been used in several other places. --Auth.

1-3037. Howell, B.F., Jr., A.B. Andrews, and R.E. Huber. PHOTOMECHANICAL METHOD OF

FREQUENCY ANALYSIS OF SEISMIC PULSES: Geophysics, v. 24, no. 4, p. 692-705, 10 figs. incl. illus., graphs, table, Oct. 1959, 6 refs.; also pub. as: Pennsylvania State Univ., College of Mineral Industries, Contr. no. 58-62.

The harmonic analysis of a seismic pulse performed by a photomechanical wave analyzer is analytically related to the Fourier integral analysis of this aperiodic pulse. The calculated integral spectra of 3 simple analytical pulses are compared to the spectra obtained from this wave analyzer. The integral analyses of 2 seismic pulses are compared to the harmonics obtained through numerical analysis.

The frequency range of the integral analysis which can be performed by this analyzer is from 5 to 300 c. p. s. Integral analyses of recorded seismic pulses up to 6 in. long (0.10 sec.) and with peak amplitudes up to 0.69 in. can be performed by this analyzer. From an evaluation of the equipment and operational errors involved in the measurements, the integral approximations obtained from the analyzer are estimated to be accurate on the average to within one db in the frequency range of 5 to 100 c. p. s. For frequencies greater than 100 c. p. s. this accuracy will decrease. This is as great an accuracy as is usually obtained by numerical analysis. --Auth.

1-3038. Vassilyev, Yu. I., O.I. Kovalev, and I.S. Parkhomenko. INVESTIGATION OF THE INCOMPLETELY MASKED CRYSTALLINE BASEMENT BY THE REFRACTED WAVE METHOD II: Akad. Nauk. SSSR, Bull., Geophysics Ser., in translation, 1958, no. 5, p. 323-328, illus., map, 4 graphs, pub. Sept. 1959, 17 refs.

The results of the experiments in the Volga-Ural area [U. S. S. R.] described in a previous paper are discussed in some detail. Some kinematic and dynamic characteristics of refracted head waves in the case of small velocity difference between media, under conditions of incomplete screening are examined. The effects of screening are calculated quantitatively, and questions of the interpretation of the recorded waves are examined.

The low frequency modification of the refraction method, using frequencies below 10 cycles per sec., diminishes the effect of partial screening of waves refracted along the basement surface (t_2) and suppresses those refracted within the overlying carbonate complex (t_1) which interfere, so that the t_2 waves may appear at distances not far from the shot point. The method should resolve basement features of the order of 100 to 200 m. in amplitude and dips not less than 1 or 2°; at present, with velocities in the lower terrigenous complex inaccurately known, it can come within 20 to 25% of the true basement relief. Boreholes in the northern part of the area investigated showed satisfactory agreement between seismic and geologic data, 10 to 15% differences in the southwestern part. --S. T. Vesselowsky (courtesy Geophysical Abstracts 175-369).

1-3039. Richards, T.C. BROADSIDE REFRACTION SHOOTING: Geophysics, v. 24, no. 4, p. 725-748, 11 figs., Oct. 1959, 3 refs.

The 3-dimensional refraction trajectories and travel times in seismic broadside refraction shooting across simple steeply dipping or faulted hypothetical structures are determined when the shotpoint is displaced from the axis. No curved surfaces are assumed, and the diffractions to be expected from the structural discontinuities are evaluated. An approximate method for correcting arc time measurements taken over the opposite side to that of the shotpoint is investigated, while the conversion of times to dip is discussed. Discussion is also given to the differences in the diffraction time curves caused by changing the shotpoint from the up to the down side of a fault and the relationship these curves have with the refraction time curves in both arc and broadside shooting.

The results of these studies indicate the care that should be taken in distinguishing between refracted and diffracted events and in relating a measured broadside time to a particular point on the refractor. The latter may lead to significant error when simple mid-point depth computations, often resorted to in field work, are employed. --Auth.

1-3040. Karus, E.V. THE ABSORPTION OF ELASTIC VIBRATIONS IN ROCKS DURING STATIONARY EXCITATION: Akad. Nauk. SSSR, Bull., Geophysics Ser., in translation, 1958, no. 4, p. 249-254, 6 graphs, 2 tables, pub. Aug. 1959, 32 refs.

The propagation and absorption of seismic waves are being investigated by a seismo-acoustical method which is based on amplitude-phase measurements of elastic vibrations induced by a source of stationary harmonic oscillations in the rock. The different wave types which are superimposed are longitudinal, transverse, and surface waves, whereby the surface and transverse waves prevail. The results of this experimental study of the elastic and absorbing properties of rocks in their natural occurrence enable us to differentiate these rocks by their absorption parameters, and to determine the physical characteristics of the propagation of elastic waves in such rocks. The obtained results are in agreement with the absorption theory of seismic waves which takes into account the elastic afterworking in rocks. --Auth.

1-3041. Treitel, Sven. DISCUSSION OF INTERNAL FRICTION OF FINE GRAINED LIMESTONES. Reply by Isidore Zietz and Louis Peselnick: Geophysics, v. 24, no. 4, p. 823-824, Oct. 1959.

A discussion of GeoScience Abstracts 1-1192, with reply by the authors.

1-3042. Volarovich, M.P., and Z.I. Stakhovskaya. THE STUDY OF YOUNG'S MODULUS OF ROCK SAMPLES UNDER PRESSURES OF UP TO 5000 kg/cm^2 BY THE METHOD OF BENDING: Akad. Nauk. SSSR, Bull., Geophysics Ser., in translation, 1958, no. 5, p. 329-335, diag., 9 graphs, 3 tables, pub. Sept. 1959, 20 refs.

The Young's modulus of different rocks (basalt, gabbro, labradorite, syenite, marble, and sandstone) was measured by the static method at hydrostatic pressures ranging up to 5, 000 kg. per cm.^{2}, which corresponds to a depth of 20 km. in the earth's crust. The apparatus is described. Careful attention was given to exact measurement of the stresses applied and the deformation, using a dynamometer and "deformometer" for the purpose. It was found that Young's modulus increases rapidly at pressures up to 1, 000 kg. per cm.^{2}, less rapidly from there to 5, 000 kg. per cm.^{2}. If the specimens were coated with Cu foil, their Young's modulus was increased 30 to 70%; this is explained as the effect of closing of the pores. The results are presented in numerous graphs and a table. --S. T. Vesselowsky (courtesy Geophysical Abstracts 175-91).

1-3043. Horton, C.W. A LOSS MECHANISM FOR THE PIERRE SHALE: Geophysics, v. 24, no. 4, p. 667-680, 2 diags., 6 graphs, 2 tables, Oct. 1959, 14 refs.

A theoretical study is made of a fairly simple model of an elastic solid in which losses are attributed to both the shear modulus and the bulk modulus. Each of these elastic parameters is represented by a circuit containing 2 springs and 1 dashpot. This is a modification of the usual Kelvin solid that has finite stiffness at infinite frequency. The 4 relaxation times introduced in the model are determined to fit the experimental data presented by McDonal et al. It is shown that one can obtain a very good representation of their experimental data with the model described above. The wave equation for an elastic solid is given in a canonical form so that one can compare easily the behavior of different models of the elastic parameters. --Auth.

1-3044. Silaeva, O.I., and O.G. Shamina. THE DISTRIBUTION OF ELASTIC PULSES IN CYLINDRICAL SPECIMENS: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 1, p. 17-24, 6 graphs, 6 seismograms, pub. 1959, 34 refs.

Descriptions are given of experiments on the distribution of elastic pulses in metal specimens of cylindrical form. The experiments were conducted using the ultrasonic pulse method and the method of longitudinal profiling. It has been established that longitudinal waves may be propagated in the specimens with 2 wave velocities: with velocity V_{P_M} equal to velocity of distribution of longitudinal waves in an infinite medium, and with velocity V_{P_R} equal to velocity of propagation of longitudinal waves in a thin rod. The relationships between the cross-sectional dimensions of cylindrical specimens and the length of the longitudinal wave have been determined, which is necessary for the calculation of velocities of longitudinal waves in the specimens. --Auth.

1-3045. Knopoff, Leon, and Anthony F. Gangi. SEISMIC RECIPROCITY: Geophysics, v. 24, no. 4, p. 681-691, 3 figs., Oct. 1959, 9 refs.; also pub. as: California, Univ. (Los Angeles), Inst. Geophysics, Pub. no. 118.

The reciprocity relationship describing the relations among the fields resulting from the interchange of point sources and receivers may be extended to the seismic case. Seismic reciprocity can be described either in terms of the scalar product of the vectors representing the excitation of the source and the field at the receiver, or in terms of a Green's tensor describing these 2 quantities. Theoretical reciprocity relations give no information concerning reciprocity in the cases for which the scalar product vanishes. A simple experiment in the vector case demonstrates that reciprocity is not obtained when the scalar product of the 2 vectors vanishes. --Auth.

1-3046. Babich, V.M., and A.S. Alekseev. A RAY METHOD OF COMPUTING WAVE FRONT INTENSITIES: Akad. Nauk. SSSR, Bull., Geophysics Ser., in translation, 1958, no. 1, p. 9-15, 3 diags., pub. 1959, 28 refs.

Equations which give a geometric approximation for the case of nonstationary waves in an inhomogeneous elastic medium are obtained with the aid of the theory of generalized functions; analogous equations are obtained by expanding stationary solutions for the case of high frequencies. Assumptions which permit the application of the equations developed in this paper to a large class of wave intensities are elaborated. --Auth.

1-3047. Parkhomenko, I.S. THE INTENSITY OF A HEAD WAVE DURING ITS PASSAGE THROUGH A HIGH-VELOCITY LAYER, STUDIED ON MODELS: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 4, p. 255-259, diag., 7 graphs, pub. Aug. 1959, 11 refs.

The paper sets out the results of an experimental study of the change in intensity of a refracted head wave during its passage through a high-velocity layer. Cases in which the wave strikes the layer at angles smaller than, equal to, and greater than the critical angle for longitudinal waves are examined. The relationship between the amplitude of the head wave and the ratio of the thickness of the layer to the wave length was studied. The results of the investigation agree with the findings obtained from other experiments, and in some cases with the results obtained from theories for stationary vibrations. --Auth.

1-3048. Zvolinsky, N.V. REFLECTED WAVES AND HEAD WAVES ARISING AT A PLANE INTERFACE BETWEEN TWO ELASTIC MEDIA II: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 1, p. 1-7, 10 diags., pub. 1959, 2 refs.

This is the concluding section of the study by the author on the properties of reflected and head waves. This paper deals with the head waves PSP and PSS appearing against the background of preceding waves PPP and PPS, and PP and PS waves in the zone beyond the critical angle of reflection. From the theory expounded approximate formulas can be derived, valid in the zones adjoining the waves under consideration. The reflected waves PP and PS preserve their shape (that of the incident wave) up to the initial point of the head wave.

For the head waves PPP and PPS the shape of vibrations is obtained by the integration of the functions describing the shape of the incident wave. The shape of the reflected waves PP and PS changes beyond the first point of the head wave, where a term is added to it conjugated with the shape of the incident wave. The head waves PSP and PSS are also composed of 2 terms. One is the repetition of the waves PPP and PSP; the second is a conjugate expression. The intensity of vibration (amplitude) of separate waves is determined not only by their type, properties of the medium and amplitude of incident waves, but also by their shape. --S. T. Vesselowsky (courtesy Geophysical Abstracts 173-131).

1-3049. Berzon, I.S. EXPERIMENTAL DATA ON CONVERTED REFRACTED PSP WAVES: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 6, p. 397-406, 18 figs. incl. graphs, seismograms, 3 tables, pub. Oct. 1959, 26 refs.

Converted refracted waves PSP are encountered only in areas where the basement is granite; therefore their presence or absence can be used as an indication of the lithologic nature of the basement. PSP waves are characterized by a wider variation of kinematic and dynamic properties (limiting velocity, amplitudes, frequency) than longitudinal refracted waves PPP. As a rule their predominant frequencies are lower than those of longitudinal waves. Over a horizontal refracting boundary they also have higher damping coefficients. Further study of this phenomenon is recommended with a view to creating a universal method of seismic exploration using the entire range of different waves, not only a certain type. Many seismograms obtained in the field are reproduced in the article. --S. T. Vesselowsky (courtesy Geophysical Abstracts 175-368).

1-3050. Yakovlev, A. F. THE SHAPE OF THE EFFECTIVE AND THE RECORDED ANOMALIES FOR AERO-GAMMA SURVEYS: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 5, p. 336-341, 10 graphs, table, pub. Sept. 1959, 5 refs.

An approximate equation is derived for the curves of the anomalies of the gamma-ray field in the atmosphere near the earth's surface. The solution is later extended to the problem of determination of these anomalies in the case of measurement by an airborne radiometer provided with an integrating element. Proof is presented that many types of anomalies often met in airborne gamma surveying are well approximated by the Gauss curve, which contains a parameter determined by the dimensions of the line of observation and its position with respect to the surveyed profile. This analysis permits solutions of the inverse problem. --S. T. Vesselowsky (courtesy Geophysical Abstracts 174-315).

1-3051. Yakovlev, A. F. SOME WAYS OF SOLVING THE DIRECT PROBLEM OF THE AERO-GAMMA-METHOD: Akad. Nauk. SSSR, Bull., Geophysics Ser., in translation, 1958, no. 1, p. 41-45, 10 figs. incl. diags., graphs, pub. 1959, 3 refs.

Here are considered approximate graphic methods for the solution of 2 basic classes of problems which are encountered in the calculation of the gamma-field, created near the earth's surface by gamma-radiation of rocks. The first class embraces the problems of calculation of the gamma-field in an absorber (air) over the plane surface of a gamma-radiating layer of rocks with an arbitrary distribution of zero gamma-field; the second class includes 2-dimensional problems with curvilinear surfaces of a radiating layer of rocks and with an arbitrary distribution of zero intensity on the surface. These questions are relevant to the direct problem of aero-gamma-method. --Auth.

1-3052. Johnson, Gerald W., Gary H. Higgins, and Charles E. Violet. UNDERGROUND NUCLEAR DETONATIONS: Jour. Geophys. Research, v. 64, no. 10, p. 1457-1470, map, profile, diag., 5 graphs, 14 tables, Oct. 1959, 21 refs.

Since 1952 8 nuclear explosions have been fired underground at the Atomic Energy Commission's Nevada test site. The explosions varied in energy release from 55 tons to 19,000 tons of TNT equivalent. Depths of burial varied from shallow, to produce cratering, to deep, where no visible effects appeared on the surface. The major experimental data from these explosions, as well as the phenomenology of the deeper shots are summarized here.

1) The radioactivity of nuclear explosions in the kiloton range in tuff can be essentially contained underground at depths of $D = 400\ W^{1/3}$ ft. or greater.

2) The initial cavity formed by the explosion has a radius of $R = 50\ W^{1/3}$ ft.

3) Initially melted rock, which is converted to glass on cooling, amounts to 500 ± 150 tons per kiloton of released energy.

4) The collapse of the cavity produces a zone of about 70,000 yds.^{3}/kt. (120,000 tons/kt.) of broken permeable material.

5) The major portion (65 to 80%) of the gross fission-product activity is in dilute (1 part per 10,000,000) solution in glass. The remainder (20 to 35%) is distributed throughout the collapsed zone of the chimney and is deposited on the surface of the broken material.

6) About 30% of the total energy released by the explosion is initially deposited in steam and hot rock at a temperature in excess of 1,200°C. This temperature rapidly degrades to the boiling point of water. One year after the Rainier explosion this energy resided within a volume whose radius was less than 80 ft. --Auth. abs. and summ.

1-3053. Zharkov, V. N. ON THE ELECTRICAL CONDUCTIVITY AND TEMPERATURE OF THE EARTH'S MANTLE: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 4, p. 260-266, diag., graph, 2 tables, pub. Aug. 1959, 14 refs.

The experimental data of Coster and Hughes on the effect of temperature and pressure on the electrical conductivity of peridotite combined with the variation of compressibility with depth determined from seismic data have enabled us to obtain the value of the ionic electrical conductivity in the earth's mantle. This enables us to obtain the temperature variation in the earth's mantle. Our treatment differs from those given earlier by taking into account the dependence of the compressibility on the pressure. A formula is given for the dependence of the melting point temperature on the pressure. It is assumed that melting occurs when the density of defects in the crystalline solid attains a certain value. It is suggested that a sharp increase in the electrical conductivity in the transition layer (at a depth of 400-700 km.) is associated with a transition to an impurity semiconductor conductivity. --Auth.

1-3054. MacDonald, Gordon J. F. CALCULATIONS ON THE THERMAL HISTORY OF THE EARTH: Jour. Geophys. Research, v. 64, no. 11, p. 1967-2000, 13 graphs, 26 tables, Nov. 1959, 84 refs.; also pub. as: California, Univ. (Los Angeles), Inst. Geophysics, Pub. no. 153.

The possible thermal history of a spherically symmetric earth is studied by comparing numerical calculations of the development of temperature within a number of model earths with observations on the present thermal state of the earth. The pertinent observations are the following: 1) the average surface heat flow is 50 ergs/cm.^{2}sec.; 2) the mantle of the earth is solid; 3) the electrical conductivity increases rapidly in the outer few hundred kilometers of the earth. It is shown that models which incorporate a wide range of initial conditions and distributions of radioactivity reproduce in a qualitative fashion the electrical conductivity of the earth. Models which have a radioactive content equal to an earth composed of chondritic meteorites reproduce the present surface heat flow to within a factor of 2. This is a consequence of the near coincidence of the present rate of heat production in a chondritic earth and the heat flux of the actual earth. The variability in heat flow among models is due to varying contributions of "initial heat," higher rate of radioactive heat production in the past, and the depth of burial of heat sources. The solid nature of the mantle provides a further qualitative restraint on possible earth models. However, a lack of experimental data on melting relations at high pressures precludes detailed conclusions.

The general features of temperature-depth curves are similar for many models in which energy is transmitted by radiation as well as by ordinary lattice conduction. The gradient of temperature is high near the surface but decreases within the earth as the effective conductivity increases with increasing temperature. The melting temperature is most closely approached or exceeded in the outer few hundred kilometers of the earth.

The variation of surface heat flow with time is examined. It is shown that the surface heat flow is constant in time for a wide range of models, provided that heat is transmitted solely by radiation and conduction. --Auth.

1-3055. Dergunov, I.D. THE MODERN CONCEPTION OF THE THERMAL CONDITIONS OF THE EARTH'S CRUST: Akad. Nauk SSSR, Bull., Geophysics Ser., in translation, 1958, no. 1, p. 35-39, map, sec., 3 tables, pub. 1959, 13 refs.

The thermal condition of the earth's crust is explained by the heat of radioactive disintegration; the theoretical conclusions agree with experimental data. The principal difficulty in solving certain questions relating to the thermal condition of the earth's crust consist in the fact that a) we do not know to what depths the radioactive elements spread out, b) how their concentration varies as far as depth is concerned, and c) how the process of change of the concentration of radioactive elements in the volume of the earth proceeded in the past and how it proceeds now.

There are very few experimental investigations for studying the thermal condition of the earth's crust on the whole planet, particularly for studying the heat flows. These experiments are conducted with insufficient accuracy and therefore cannot always be used for conclusions and generalizations.

Taking into consideration the exceptional importance of the study of the thermal condition of the earth's crust for the purpose of using the heat energy of the earth in the national economy, and for the development of knowledge of the internal structure of the earth, it is necessary that such studies be expanded in our country. --Auth. concl.

1-3056. Von Herzen, R., and Arthur E. Maxwell. THE MEASUREMENT OF THERMAL CONDUCTIVITY OF DEEP-SEA SEDIMENTS BY A NEEDLE-PROBE METHOD: Jour. Geophys. Research, v. 64, no. 10, p. 1557-1563, diag., 2 graphs, 4 tables, Oct. 1959, 13 refs.

The transient heating of a needle probe is used to measure the thermal conductivity of deep-sea sediments in 10 min. or less. An accuracy of 3 to 4% compares favorably with steady-state methods, and measurements by both methods on the same sediments show good agreement. Thermal diffusivity of deep-sea sediments is shown to be proportional to thermal conductivity, in agreement with theoretical expectations. --Auth.

7. GEOCHEMISTRY

See also: Mineralogy 1-3102; Mineral Deposits 1-3146.

1-3057. Abelson, Philip H., ed. RESEARCHES IN GEOCHEMISTRY: 511 p., illus. incl. maps, charts, diags., graphs, tables, New York, John Wiley & Sons; London, Chapman & Hall, 1959, refs.

The Geophysical Laboratory of the Carnegie Institution of Washington organized a seminar series in geochemistry, held at the Laboratory and at the Johns Hopkins University during 1957-1958. At the conclusion of the series the papers comprising Researches in Geochemistry were assembled. Topics were chosen to provide a cross section of current research activity in numerous areas of inquiry. Each essay reviews the present status of research in its specific area, describes the author's recent contributions, and contains an extensive selected bibliography. --From ed. pref.

The 23 papers follow, each abstracted separately, in the order in which they appear in the volume.

1-3058. Arrhenius, Gustaf O.S. SEDIMENTATION ON THE OCEAN FLOOR (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 1-24, 4 illus., 4 maps, sec., 3 profiles, 4 graphs, New York, John Wiley, 1959) 47 refs.

This article reviews components, chronology, and geological record of sedimentation in oceans of the world. There are 4 types of sediment components: 1) lithogenous (quartz, feldspars, and micas are the most stable); 2) hydrogenous (clay minerals, zeolites, principally phillipsite; nodular Mn plus iron oxides; apatite; barite, occuring mainly between 5°N. and S. of equator); 3) biogenous (skeletal remains of plants and animals; in decreasing order of solubility are aragonite, calcite (concentration, 0-5 cm.·millenium^{-1}), opal, apatite, phosphatic debris (internal surface of fish debris is 100-200 m.^{2}·g.$^{-1}$, hence its efficiency in scavenging heavy metals from sea water); and 4) cosmogenous (spherical droplets of Ni-Fe, 15-230 micron diameter, and accumulating at rate of 4 x 10^{-8} g.·cm.·millenium^{-1}).

In dating sediments the following are discussed: radiocarbon (biogenous calcite); accumulation of Ti; radioactive Be^{10}; K-A, age range 10^{7} to 10^{8} years, of glauconite; Re^{187} decaying to Os^{187} is potentially useful; Io/Th ratios. Ra has been found concentrated in phillipsite and hydrogenous barite. Th isotopes are concentrated in ferromanganese oxide-hydrate minerals, apatite of fish debris, but not in clay minerals.

Ocean floor sediments have been penetrated to a depth of 15 m., so that only Recent and Plio-Pleistocene are known. Topographic highs on ocean floors have yielded Tertiary sediments. Seismic data give sediment thicknesses of 200-300 m. over large areas of the Pacific floor. O isotope data indicate that the temperature of middle and deep water during early and middle Tertiary was 10°C. higher than at present. High ratio of hydrogenous to lithogenous minerals indicates that there was less mechanical weathering on continents during the Tertiary than now. --D. Carroll.

1-3059. Garrels, Robert M. RATES OF GEOCHEMICAL REACTIONS AT LOW TEMPERATURES AND PRESSURES (In: Abelson, Philip H., ed. Researches

in Geochemistry: p. 25-37, diag., New York, John Wiley, 1959) 10 refs.

Studies of rates and mechanisms of selected reactions can be of much help to the geologist. The reactions among dissolved species are generally rapid, except for the formation or breakdown of polymeric ionic species. Some geologically important reactions, such as oxidation by dissolved O or reduction of sulfate ions to S or sulfide are extremely slow.

The formation of precipitates from homogeneous solution is ordinarily rapid, except for carbonates and silicates. The first precipitate formed, however, although it is in equilibrium with the solution, is seldom stable with respect to other solid phases.

Changes in such metastable precipitates may involve simple aging and splitting-out of water. Many processes which are normally slow, such as equilibration between $(H_4SiO_4)_n$ and quartz may be speeded up by intervention of organisms. The occurrence of the metastable phase of a dimorphous pair also may be related to the kinetics of formation of the phases. The formation of some stable phases from an intermediate metastable phase may entail marked compositional change. The rate of congruent solution of solids appears to be related to grain size, provided the solubility of the mineral exceeds 0.01 mole per liter. Otherwise no predictions can be made. In an incongruent solution of a mineral the possibility of armoring a metastable phase by a stable phase must be considered. An armored phase will persist indefinitely. This mechanism is important in preventing the formation of clays from feldspars in many environments. --A. M. Pommer.

1-3060. Keith, Mackenzie L., and Egon T. Degens. GEOCHEMICAL INDICATORS OF MARINE AND FRESH-WATER SEDIMENTS (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 38-61, 6 graphs, 2 tables, New York, John Wiley, 1959) 58 refs.

Trace-element analyses of sedimentary rocks may provide a number of criteria for differentiating rocks of marine origin from those of fresh-water origin. The most promising are elements of the marine chemofacies, such as B, Li, S, and F.

An element like B, which is in a relatively insoluble form of combination in the sedimentary rocks studied, has some advantage over F and S which are more susceptible to post-depositional removal and are therefore less satisfactory for environmental study of weathered rocks.

Trace-element data for the separated fractions of sedimentary rocks are more easily interpreted than data for untreated rock samples, and they permit comparison of rocks of different bulk composition. For example, data on the trace-element content of sandstones are almost meaningless because of the wide variability in proportions of grains and matrix material and in the relative amounts of clay minerals, carbonates, organic material, etc., in the matrix. The trace-element assemblage of the clay fraction, however, can usefully be compared from one sandstone to another. Trace-element analyses of raw samples probably are significant only for rocks in which one fraction (for example, the clay fraction in shales) is greatly predominant.

The general utility of the proposed criteria remains to be demonstrated for rocks of other ages and geographic areas. Very likely environmental diagrams will have to be constructed for different sedimentary basins, by initial analyses of a group of known marine and fresh-water samples.

For the Pennsylvanian stratigraphic sequence studied, it appears possible to differentiate marine and fresh-water shales, or sandstones, by means of 2 of the selected criteria, for example by B and Li analyses. Environmental diagnosis by trace elements can be more generally applied and can be improved (in the sense of increasing the percentage of correct determinations) if a number of trace elements are used in conjunction, either in a multivariant plotting model or in an equation derived from a multivariant analysis of the trace-element data.

If detrital and post-depositional carbonates can be avoided or allowed for, the C^{13}/C^{12} ratio of carbonate C in limestones and sandstones appears to offer an environmental criterion that may be widely applicable to studies of stratigraphy and paleogeography. --Auth. concl.

1-3061. Hawkes, H.E. GEOCHEMICAL PROSPECTING (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 62-78, map, sec., graph, 2 tables, New York, John Wiley, 1959) 19 refs.

Hawkes defines and discusses several of the new terms peculiar to geochemical prospecting such as geochemical anomaly, threshold, contrast, primary and secondary anomalies, mobility of the elements, and follows this with a brief discussion of the common mechanisms of dispersion of the elements such as glacial transport, transport by subsurface water, transport by surface water, and the special case of residual anomalies where no appreciable transport is involved. Geochemical prospecting is defined as mineral exploration based on the systematic measurement of one or more chemical properties of a naturally occurring substance, and some of the techniques used in studying the various dispersion phenomena are summarized with examples. As a case history, the Black Bird Co district of Idaho is discussed at length. Here the interbedded quartz biotite schist and fine-grained quartzites of the Belt series are cut by a number of shear zones that carry cobaltite, chalcopyrite, pyrite, and pyrrhotite. Soil samples collected at 100-ft. intervals along many traverses showed that a 2-man team could cover 5,000 to 15,000 ft. of traverse per day; the samples collected clearly defined an area of anomalously high Co (greater than 80 p.p.m. Cu and more than 30 p.p.m. of Co). Within the anomalous area of 3 sq. mi., Hawkes estimates that at least 250 tons of Co per foot of depth have been introduced - an amount several hundred times as great as found in all the known deposits of the district. The soil sampling showed that the Black Bird district could have been found by geochemical sampling even on a grid of one mile centers.

Several inadequately explored major geochemical problems are considered. It seems probable that metallogenetic provinces may be betrayed by geochemically anomalous amounts of the economic elements in the igneous rocks of the area; leakage halos above ore bodies in bedrock may be detectable; an understanding of the mechanism of fixation of trace elements in soils and sediments would help greatly in interpreting geochemical prospecting data and in devising the proper technique for the most significant type of analysis. Halos caused by the migration of ions upward into overburden above an ore outcrop should theoretically cause an electric field, the polarity of which is actually the opposite of that suggested by the theory of the oxidation of sulfide minerals at the upper end of an electonic conductor, a paradox that raises interesting questions.

The mobility of elements in weathering as indicated by the ratio of the percentage of the element in the residue from water to the percentage present in the average terrain over which the water has moved, is considered, and contributions of various investigators are appraised. Hawkes concludes that the mobility so measured is: Mg > Ca > Na > K > Si > Al > Fe. --T. S. Lovering.

1-3062. Abelson, Philip H. GEOCHEMISTRY OF ORGANIC SUBSTANCES (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 79-103, 3 diags., 2 graphs, 9 tables, New York, John Wiley, 1959) 51 refs.

A review of sources of naturally occurring organic substances. Proteins, lipids, carbohydrates, and porphyrins are discussed. Thermodynamic data are presented to demonstrate relative stabilities of a series of amino acids. In solution between 200° and 250°C., alanine, glycine, glutamic acid, leucine, isoleucine, proline, and valine are relatively stable (E about 44,000 cal./mole); aspartic acid, lysine, and phenylalanine are moderately stable; and serine, threonine, arginine, and tyrosine are relatively unstable. --I. A. Breger.

1-3063. Hanson, William E. SOME CHEMICAL ASPECTS OF PETROLEUM GENESIS (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 104-117, 4 diags., New York, John Wiley, 1959) 52 refs.

A review of present-day thinking on the origin of petroleum with particular emphasis on contributions from lipids and proteins. It is concluded that: crude oil, as we know it, has not formed in recent sediments; source material other than plant- and animal generated hydrocarbons must be involved; polyene pigments and proteins are potential sources of hydrocarbons; and thermal degradations over long periods of time may produce hydrocarbons from substances such as amino acids. --I. A. Breger.

1-3064. Milton, Charles, and Hans P. Eugster. MINERAL ASSEMBLAGES OF THE GREEN RIVER FORMATION (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 118-150, 5 illus., map, 11 diags., 2 tables, New York, John Wiley, 1959) 52 refs.

In this paper an outline of the geological conditions that prevailed during the deposition of the Green River [Eocene] sediments is given, and the saline and nonsaline minerals found in these rocks are described. It is pointed out that there was a gradual subsidence of the lake basin that at times exceeded the rate of sedimentation, thereby making possible the accumulation of more than 7,000 ft. of lacustrine sediments.

A table lists 17 carbonate minerals, 3 of which, shortite $Na_2Ca_2(CO_3)_3$, eitelite $Na_2Mg(CO_3)_2$, and an unnamed anhydrous barium-magnesium carbonate $BaMg(CO_3)_2$, are unique to the Green River formation. One carbonate-phosphate mineral, bradleyite $Na_3PO_4 \cdot MgCO_3$, was originally described from the Green River formation, and the rare carbonate-chloride mineral, northupite $Na_2CO_3 \cdot MgCO_3 \cdot NaCl$, is also listed. The table lists 13 silicate minerals, 3 of which, garrelsite $(Ba, Ca, Mg)B_3SiO_6(OH)_3$, loughlinite $(Na_2 Mg)_2Si_3O_6(OH)_4$, and reedmergnerite $NaBSi_3O_8$ have been found only in Green River rocks. The sulfides pyrite, marcasite, pyrrhotite, and wurtzite are listed; also quartz. There are 2 phosphates, fluorapatite $Ca_{10}(PO_4)_6F_2$, and collophane $Ca_{10}(PO_4)_6CO_3 \cdot H_2O$, and an unnamed sodium-magnesium fluoride listed in the table. Four sulfates and 8 hydrocarbons complete the list.

A P_{CO_2}-T diagram of the system $NaHCO_3$-Na_2CO_3-H_2O marks the phase boundaries of the hydrates of sodium carbonate, trona, and nahcolite. Another P_{CO_2}-T diagram shows a portion of the system $NaHCO_3$-Na_2CO_3-$CaCO_3$-H_2O.

A photomicrograph of a thin section shows detrital brown hornblende with secondary blue regenerated amphibole. In another photomicrograph hornblende grains are seen with secondary riebeckite. The unusual forms of pyrite crystals from the trona mine, Wyoming, are shown in a photomicrograph. --J. J. Fahey.

1-3065. Libby, W. F. TRITIUM IN HYDROLOGY AND METEOROLOGY (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 151-168, diag., 4 graphs, 7 tables, New York, John Wiley, 1959) 17 refs.

It has been clear from the beginning of the researches on the tritium produced by cosmic radiation that the labeled water resulting from the production of tritium in the higher levels of the atmosphere would be of real usefulness in hydrologic and meteorologic studies, and initial results justified these expectations. In the spring of 1954 man-made tritium produced by the thermonuclear weapons tested in the Pacific created a new and abundant source larger than the cosmic rays themselves, which because of its placement in time was in some ways more useful for measurements of rates of natural water processes. More recently, the use of reactor-produced tritium in planned experimentation is showing rich promise as a tool for research.

This paper reviews some of the findings stemming from nuclear tests, including atmosphere storage time for water; Castle bomb tritium deposition in the northern hemisphere; ground-water inventory, storage times, and water balance for the northern Mississippi Valley; surface ocean mixing rates; and regional hydrologic applications. It concludes with a brief description of possible uses of synthetic tritium in studies of local hydrology. --From auth. introd.

1-3066. de Vries, Hessel. MEASUREMENT AND USE OF NATURAL RADIOCARBON (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 169-189, chart, 3 diags., 2 graphs, New York, John Wiley, 1959) 32 refs.

This paper, by one of the world's top researchers of C^{14}, not only reviews the field, but also presents important new developments. The author discusses the extension of the C^{14} dating range by isotopic enrichment, which allows him to date samples of 70,000 years age. A curve of the climatic fluctuations during the last 70,000 years is included. Purification of the sample, so very necessary in dating samples of such great antiquity, is discussed. The variations in initial C^{14} activity for the past 500 years are plotted along with the historic retreats and advances of glaciers. These show a fair degree of parallelism. To investigate how these variations affect the exchange and balance of the various C^{14} reservoirs, the author has constructed an electric analogue. The error in a C^{14} date due to these variations of initial activity is probably less than 1% or 80 years. If the variations correlate with solar activity, the glaciations probably are caused to some degree by solar fluctuations. --M. Rubin.

1-3067. Tilton, G. R., and Gordon L. Davis. GEOCHRONOLOGY (In: Abelson, Philip H., ed. Re-

searches in Geochemistry: p. 190-216, 4 maps, 9 tables, New York, John Wiley, 1959) 49 refs.

The methods, results, and conclusions of geologic age research of the past decade are reviewed with emphasis on the broad geologic implications. The significance of concordance between results of the Pb methods, the K-A method and the Rb-Sr method on different minerals from the same rock is discussed, and natural processes that may result in discordant ages are outlined.

Several large portions of North America are underlain by rocks which give essentially uniform concordant ages within each portion. These ages are approximately: 100 million years on the West Coast; 180-370 million years on the East Coast (Appalachian region); 1,000-1,150 million years from southern Ontario into the Appalachian region, with similar ages measured in Colorado and central Texas; 1,300 to 1,450 million years in the southwestern United States; and 2,600-2,700 million years in a belt from the Lake Superior region to Montana and Wyoming. Similar age provinces appear to exist on other continents, and the age patterns do not support the simple hypothesis of continental growth by accretion along the margins.

Age studies of metamorphic rocks show that in the Appalachian region feldspars and zircons may preserve the nearly concordant age of about 1,100 million years, but biotite gives ages around 350 million years. In contrast, zircons in the Laramide belt (Colorado) are discordant. The available age data are not yet sufficient to permit the establishment of a numerical geologic time scale. --H. Faul.

1-3068. Epstein, Samuel. THE VARIATIONS OF THE O^{18}/O^{16} RATIO IN NATURE AND SOME GEOLOGIC IMPLICATIONS (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 217-240, illus., 3 diags., 4 tables, New York, John Wiley, 1959) 28 refs.

A review is presented of some of the recent studies on the O-isotope composition of naturally occurring O-containing materials, as examples of applying stable isotopes to the study of natural processes. The isotopic fractionation factor α is defined, and shown to be temperature-dependent but insensitive to effects of factors such as pressure, chemical composition, etc.

The O^{18}/O^{16} ratio is measured by comparing mass 46 ($C^{12}O^{16}O^{18}$) with mass 44 ($C^{12}O^{16}O^{16}$) in a Nier-type mass spectrometer. The variations of the O^{18}/O^{16} ratio are recorded as deviations from a standard, mean ocean water.

The O^{18}/O^{16} variation in natural waters is discussed. The relationship between the O^{18} abundance and salinity indicates that the water removed from the ocean has a lower O^{18}/O^{16} ratio than the vapor in equilibrium with the oceans, explained by suggesting that the meteorological cycle is like a multiple-stage still with reflux. The O^{18}/O^{16} ratio is affected by such factors as latitude, altitude, climate, and temperatures.

Researches in paleotemperatures, using the O-isotope temperature scale, are discussed.

Common rock systems are usually composed of 2 or more coexisting minerals. If these minerals were in isotopic equilibrium with one another at the time of crystallization, it is possible to determine the temperature of equilibration. If the minerals are not all in equilibrium, it is possible from the O-isotope data to draw conclusions about the paragenesis, degree of low- and high-temperature diagenesis, and other interesting aspects of petrology. Results of analyses of complete silicate rocks and of various mineral pairs are given. --B. Levin.

1-3069. Ault, Wayne U. ISOTOPIC FRACTIONATION OF SULFUR IN GEOCHEMICAL PROCESSES (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 241-259, illus., 3 diags. (2 fold.), graph, 6 tables, New York, John Wiley, 1959) 32 refs.

S isotopes in geochemical and biochemical processes involving a valence change such as that between sulfate and sulfide, are fractionated with the lighter isotope favoring the sulfide. The ratio of S^{32}/S^{34} in nature varies from 20.8 for sulfate in the cap rock of salt domes to 23.3 for sulfide in shales - a total variation of 11%. After a brief discussion of the research technique, the isotopic content of some important occurrences of S are summarized and discussed.

1) Isotopic ratios of meteorites are essentially constant - between 22.18 and 22.24.

2) The average S isotopic composition of igneous rocks is heavier than meteoritic S.

3) Volcanic native S has a wide range of ratios, attributed to oxidation-reduction and volatilization processes.

4) The average S^{32}/S^{34} ratio of S from hydrothermal sulfide deposits is 22.13, heavier than meteoritic S.

5) The average S of sedimentary sulfides is about 1.5% lighter than meteoritic S, though they show a wide range of ratios, to be expected from the many sources and processes involved. The heaviest are probably derived from sulfates; the lightest may be the result of successive fractionations from magnetic, volcanic, or existing sedimentary sulfides. The large isotopic variations in evaporates, if due to local conditions, may give information on paleoclimatic conditions.

6) Sea-water sulfate gives remarkably constant ratios averaging 21.76 ± 0.02.

7) Biogenic S, the heaviest in nature, is in anhydrite from the calcite cap rock of salt domes.

Various fractionation processes are discussed. The most effective are those involving oxidation-reduction, both biochemical and geochemical. Using the extensive data now available on S, the calculation of an isotopic material balance is summarized briefly. The value of average crustal S (22.14) indicates that terrestrial S is heavier than meteoritic S (22.21). --B. Levin.

1-3070. Krauskopf, Konrad B. THE USE OF EQUILIBRIUM CALCULATIONS IN FINDING THE COMPOSITION OF A MAGMATIC GAS PHASE (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 260-278, 3 tables, New York, John Wiley, 1959) 18 refs.

The nature of the volatile material associated with crystallizing magma may be investigated by a study of the equilibrium relationships between a hypothetical magmatic gas and the mineral assemblages that once were in contact with it. Hypothetical chemical reactions involving coexisting minerals and possible gaseous compounds are set up, and the equilibrium pressure of the gases is calculated from thermochemical data. If similar gas compositions are indicated by various combinations of minerals, the result will have some claim for reliability.

The major gases for which calculations were made include hydrogen sulfide, O, hydrogen fluoride, hydrogen chloride, and carbon dioxide. None of the N gases can be assigned limiting pressures, because no N minerals are known in high temperature deposits. The calculations were checked against values derived from data pertaining to volcanic gases and excess "volatiles" and, with a possible exception for hydrogen fluoride, showed internal consistency. Further limiting pressures were derived for gas phase equilibria involving H, C gases, S, sulfur dioxide, and ammonia, and possible equilibrium compositions for a reducing and an oxidizing magmatic gas phase at 600°C. were given. Volatilities of metals, metal oxides, metal sulfides, and metal chlorides at equilibrium with sulfides, oxides, or most stable phase (selected from sulfides, oxides, and silicates) at 600°C. were calculated and tabulated. From these values the total amount of any metal in a magmatic gas can be estimated. From these values it is possible to estimate the effect of a gas phase upon ore metal transport. The order of volatilities shows a vague relationship to the order in which metals are emplaced during deposition, but this relationship is not borne out in detail. It is reasonable to assume in a water-rich compressed gas that solubility effects are added to the effects of volatility; these effects may explain the discrepancies. It is impossible for any hypothesis depending on simple vapor transport to serve as a general explanation for the origin of ore deposits. --A. M. Pommer.

1-3071. Barton, Paul B., Jr. THE CHEMICAL ENVIRONMENT OF ORE DEPOSITION AND THE PROBLEM OF LOW-TEMPERATURE ORE TRANSPORT (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 279-300, 4 graphs, 4 tables, New York, John Wiley, 1959) 53 refs.

A critical discussion of the factors affecting the solution and transport of the ore minerals. The chemical environment is of major importance, and the information available from thermal springs and fumaroles, from liquid inclusions, and from phase relations is considered. The low-temperature ore-forming fluid is a dominantly aqueous solution that is relatively concentrated in sodium and potassium chloride with variable but generally minor amounts of Ca, bicarbonate, and sulfate ions, and a low content of heavy metals. Carbon dioxide usually is from 1 to 3 times as abundant as hydrogen sulfide, and the formation of CO_2-rich phase is unlikely. Because of the extremely low solubility of the ore minerals, principally heavy-metal sulfides, an acceptable method for their transport at low temperatures, up to 150°-200°C. is difficult to find. After a discussion and rejection of other factors, it is concluded that the formation of complex ions which effectively change the thermodynamic properties of the ions or molecules in question affords the most probable mechanism of transport. --G. W. Morey.

1-3072. Kullerud, Gunnar. SULFIDE SYSTEMS AS GEOLOGICAL THERMOMETERS (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 301-335, map, sec., 11 diags., New York, John Wiley, 1959) 46 refs.

Some synthetic sulfide systems and their applications to geothermometry of ore deposition are reviewed. A maximum possible temperature can be deduced from the presence of pyrite or covellite by estimating total pressure. If the deposition temperature can be estimated where pyrite and pyrrhotite or covellite and digenite occur, the S vapor pressure can be approximated. Under conditions of sufficiently high S vapor pressure and water pressure, pyrite could occur as a primary mineral in a granite but covellite could not.

In the system Fe-S-O, the assemblages pyrite-pyrrhotite-magnetite and magnetite-pyrite-hematite are stable below 675°C. Above 675°C., pyrite-pyrrhotite-hematite and hematite-magnetite-pyrrhotite are the stable assemblages. At about 700°C., pyrite + hematite $\rightleftharpoons$ pyrrhotite + SO_2. At about 743°, pyrite breaks down. In 126 deposits containing both iron oxides and iron sulfides, if one assumes a maximum temperature of 600°C., the partial pressure of O must have been less than 10^{-14} atm., and in only 13 could it have exceeded 10^{-25} atm.

The compositions of some solid solutions vary measurably with temperature and, to a much lesser extent, with pressure. Temperatures between 325° and 600°C. can be estimated from the Fe content of pyrrhotite in equilibrium with pyrite. Temperatures between 140° and 894°C. can be determined from the amount of FeS in sphalerite in equilibrium with pyrrhotite or (below about 600°) pyrrhotite plus pyrite. When sphalerite coexists with pyrite alone, the temperatures deduced by this method are almost always lower than the real temperature and should be regarded as minimum values.--E.H. Roseboom, Jr.

1-3073. Goldsmith, Julian R. SOME ASPECTS OF THE GEOCHEMISTRY OF CARBONATES (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 336-358, 4 diags., New York, John Wiley, 1959) 37 refs.

The author reviews existing laboratory studies of subsolidus carbonate phase relations. The equilibrium solid solubility of $MgCO_3$ in $CaCO_3$ (calcite) increases from about 5 mole % at 500°C. to 27 mole % at 900°C. The highly magnesian calcites precipitated by marine organisms are thus metastable. Complete solid solution exists between $CaCO_3$ and $MnCO_3$ above 550°C., but below that temperature a solubility gap is present in the Mn-rich half of the system. About 37 mole % $FeCO_3$ is soluble in calcite at 700°C., 5 mole % $CaCO_3$ in siderite at 500°C.

Equilibrium thermal decomposition curves for calcite, magnesite, dolomite, rhodochrosite, and smithsonite have been published. That for dolomite is complicated by the fact that at high temperatures and CO_2 pressures the calcite formed contains $MgCO_3$ in solid solution. The equilibrium distribution of Mg in the assemblages dolomite-magnesian calcite and magnesian calcite-periclase, and of Mn in manganous oxide-manganoan calcite have been experimentally determined. The distribution in the latter 2 assemblages is a function of P_{CO_2} as well as of temperature.

Aragonite at or near the earth's surface is shown by experimental studies using several different techniques to be metastable with respect to calcite.

In kutnohorite $CaMn(CO_3)_2$, cation disorder is observed to begin at 450°C., but the cations in dolomite remain ordered at 900°C. At that temperature about 4 mole % excess $CaCO_3$ or 1 mole % excess $MgCO_3$ can be accommodated. Dolomites from sedimentary rocks frequently show an abnormal basal plane sequence. --D. L. Graf.

1-3074. Chayes, Felix. DIFFRACTION EFFECTS OF SHORT-RANGE ORDERING IN LAYERED SEQUENCES (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 359-376, 4 illus., diag., 2 tables, New York, John Wiley, 1959) 28 refs.

An experimental approach to the structural problem of order-disorder phenomena in mineral structures is described. A hypothetical model structure of a layer type is defined, in which a given layer may have 1 or 2 possible aspects, A or B. The variations of this model are analytically described, ranging from complete disorder, where the probable aspect of any layer is determined only by the proportion of A and B present, and complete short-range order, where an A layer (A is the less abundant) is always followed by a B layer.

Experimentally, a model based on 200 layers is developed representing a desired degree of disorder and ratio of A to B. The model is prepared on an 8 x 10 in. photographic plate by a device which registers on the plate 1 layer at a time in the form of a row of 60 spots. Shifts within layer (A or B) and from layer to layer are effected by appropriate screws. The resulting image is reduced and inserted in an optical bench which produces its diffraction image.

Certain rows of "spots" in the diffraction pattern are diffuse and continuous, but show complex variations in intensity. The model with complete short-range order gives a highly characteristic pattern showing a strong pair of maxima symmetrically located halfway between the rows of sharp spots. Similar types of diffuse patterns have been observed with X-rays for certain feldspar crystals, in which a disordering of Al and Si atoms is involved. --H. T. Evans, Jr.

1-3075. Boyd, Francis R. HYDROTHERMAL INVESTIGATIONS OF AMPHIBOLES (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 377-396, 10 diags., 2 tables, New York, John Wiley, 1959) 35 refs.

In a general discussion of the structure and chemistry of the amphiboles, Boyd classifies them into 3 groups: 1) the calciferous amphiboles, such as tremolite and pargasite; 2) the alkali amphiboles such as richterite and arfvedsonite; and 3) the anthophyllite-cummingtonite group. A p-t diagram is given for the reaction: tremolite = gas + enstatite + diopside + quartz. The experimental study was made difficult by the failure of pyroxene and quartz to react with formation of tremolite, and in a zone of indifference about 20° wide the relative proportions of tremolite and of pyroxene and quartz will not change sufficiently to permit location of the curve. At 1,000 bars it is at about 835°, at 2,000 bars, 868°. The p-t curve for the reaction: gas + aluminous diopside + forsterite + nepheline + spinel + anorthite = pargasite was found to end at an invariant point at 1,025° and 800 bars. At this point 2 other univariant p-t curves intersect: in 1 of these, going to lower temperatures and higher temperatures, the assemblage of reactants which, in the reaction above yield pargasite, yield gas + aluminous diopside + forsterite + spinel; along the other, going to higher temperatures and pressures, pargasite melts with decomposition to the same group of phases. The relationship in the anthophyllite-cummingtonite series are discussed and illustrated by a hypothetical diagram. A series of preliminary diagrams worked out by W. G. Ernst for the stability fields of magnesian riebeckite are given, but no experimental details. --G. W. Morey.

1-3076. Eugster, Hans P. REDUCTION AND OXIDATION IN METAMORPHISM (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 397-426, 18 diags., 4 tables, New York, John Wiley, 1959) 28 refs.

Reduction and oxidation reactions influence the formation of rock and mineral assemblages. Quantitative aspects of redox reactions in metamorphism may be studied by clarifying the relationship between the state of oxidation of a mineral or mineral assemblage and the O pressure of the gas phase in equilibrium with it.

Isobaric sections for temperature-composition diagrams for the systems Fe-O and Fe-Si-O are presented, and the effect of the pressure of water is discussed. Isothermal sections through the system Fe-O-H and H pressure-temperature diagrams of this system at a water pressure of 1 atm. also are given.

Annite is used as illustration of a hydrous iron silicate, and its stability as a function of water and O pressure and temperature is discussed, especially with respect to its conversion to sanidine, magnetite, hematite, fayalite, and leucite.

The data presented can be applied to the "oxide-facies" of the Precambrian Fe formation of Michigan and Minnesota, to the relation of redox reactions and mineral facies, and to the problem of reduction and oxidation during metamorphism. --A. M. Pommer.

1-3077. Thompson, James B., Jr. LOCAL EQUILIBRIUM IN METASOMATIC PROCESSES (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 427-457, 13 figs. incl. 3 illus., 2 diags., New York, John Wiley, 1959) 45 refs.

A very precise and lucid account of the principle of local equilibrium and of the phase rule, as applied to metasomatic processes. The validity of the principle of local equilibrium is upheld, and Korzhinsky's phase rule for systems with mobile components is rigorously derived. The article contains a useful bibliography of Korzhinsky's writings on the subject. --J. Verhoogen.

1-3078. Reed, George W. ACTIVATION ANALYSIS APPLIED TO GEOCHEMICAL PROBLEMS (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 458-475, chart, graph, 7 tables, New York, John Wiley, 1959) 43 refs.

A comprehensive presentation is given of the general method, techniques, and equipment needed to make activation analysis. The author has centered his discussion of activation analysis about meteoritic material since meteorites are often considered to have a typical composition of cosmic matter.

The author is currently engaged in redetermining the abundances of the elements from Hg through U in meteoritic material, and gives his data for U abundance. He obtains values which in general fall in the range of 10^{-12} to 10^{-10} gU/g, values which are 10 to 10^3 lower than those reported by other workers. From this and other data in the literature a discussion is given on the abundance of U, He, and Pb in meteorites and their relation to geologic age measurements. On the basis of his arguments the author suggests that meteoritic matter accumulated about 4.5×10^9 years ago, and that about 10^9 years ago some He and Ar were lost due to thermal alteration. If the latest Th/U ratio and K data are used to calculate heat loss and generation in the earth, there is no longer an excess heat problem as pointed out by Urey some years ago. Finally, a résumé is given of the work currently being conducted in the author's laboratory on related problems. --F. E. Senftle.

1-3079. MacDonald, Gordon J. F. CHONDRITES AND THE CHEMICAL COMPOSITION OF THE EARTH

(In: Abelson, Philip H., ed. Researches in Geochemistry: p. 476-494, 10 tables, New York, John Wiley, 1959) 49 refs.

The composition of the earth's crust is estimated from chemical analyses of the surface rocks (with accompanying tables), but determining the composition of the remainder of the earth has to be by indirect means. New evidence supports the idea that the earth may have a composition similar to that of chondritic meteorites, and some of the consequences of such a hypothesis are examined.

Reasons are given why chondrites are thought to represent the best chemical model of the earth. The abundances of metallic elements in the solar atmosphere agree with the abundance of the metals in chondritic meteorites except for K and Fe. A model of the earth having Fe core and chondritic mantle would have a heat production of about 1.5×10^{20} cal./yr. Heat flow measurements on continents and oceans indicate a rate of loss of heat from the earth's interior of $1.9 (\pm 1) \times 10^{20}$ cal./yr. Thus the rate of loss of heat from the earth does not differ significantly from the rate of heat production in an earth entirely or largely composed of chondritic material. It is argued that the earth's core probably contains major amounts of Si alloyed with Fe. A study of heat loss data and steady-state temperature distributions are given, showing that the mantle must be chemically differentiated.

On the basis of a chondritic model for the earth, the upper mantle would be composed of material in which the radioactive elements are present in amounts from 1/3 to 1/10 of their abundance in basalts, though with greater abundance than in dunites. A rock intermediate in composition between eclogite and dunite would meet this requirement and also satisfy seismic requirements. --B. Levin.

1-3080. Clark, Sydney P., Jr. EQUATIONS OF STATE AND POLYMORPHISM AT HIGH PRESSURES (In: Abelson, Philip H., ed. Researches in Geochemistry: p. 495-511, 8 diags., New York, John Wiley, 1959) 30 refs.

Experimental evidence for pressure-induced phase changes in silicates is reviewed. It is concluded that some of the most drastic effects of pressure may involve heterogeneous equilibria in multicomponent systems. Electronic breakdown at very high pressure is considered possible, but probably not of major importance in the earth. Two equations of state are presented. Birch's equation, based on the Murnaghan finite-strain theory, is valid at low pressures where experimental data are available. The quantum-statistical equation of Thomas and Fermi is valid only at extremely high pressure. Comparison of the 2 equations in the case of the alkali metals suggests that the Thomas-Fermi equation does not give reliable results at pressures less than about 10^8 bars. Phase changes and equations of state cannot be predicted from existing theories for complex materials. --H. S. Yoder, Jr.

1-3081. Harker, R. Ian. THE SYNTHESIS AND STABILITY OF TILLEYITE, $Ca_5Si_2O_7(CO_3)_2$: Am. Jour. Sci., v. 257, no. 9, p. 656-667, 3 figs., 3 tables, Nov. 1959, 20 refs.

At 5, 000 lbs. /in. ^{2} of CO_2, tilleyite is stable between 930 and 970°C. and at 3, 000 lbs. /in. ^{2} of CO_2, between 870 and 930°C. The conditions of its stability are defined, on a P_{CO_2}-T diagram, by a narrow band lying between the more carbonated calcite + wollastonite assemblage and the less carbonated spurrite.

Under the conditions of the experiments it was found that traces of alumina and fluoride were necessary to effect the synthesis of tilleyite. A consideration of natural mineral assemblages currently supports the evidence that the presence of these 2 components is very effective in promoting the formation of tilleyite. With sufficient alumina, the formation of gehlenite can be detected in apparent equilibrium with calcite + wollastonite, tilleyite, or spurrite. --Auth.

1-3082. Kennedy, George C. PHASE RELATIONS IN THE SYSTEM Al_2O_3-H_2O AT HIGH TEMPERATURES AND PRESSURES: Am. Jour. Sci., v. 257, no. 8, p. 563-573, 3 graphs, table, Oct. 1959, 12 refs.

The system Al_2O_3-H_2O has been studied in the temperature range 100-600°C. and at H_2O pressures ranging from 5, 000 to 40, 000 atmospheres. At 40, 000 atmospheres pressure the maximum temperature at which the trihydrate, gibbsite, is stable is 295°. The monohydrate, diaspore, is stable at 40, 000 atmospheres of H_2O to a temperature of approximately 590°. The relations of the polymorphs, diaspore and boehmite, are discussed and it is concluded that all boehmite forms metastably. The approximate slope of the boehmite-diaspore boundary, computed from thermodynamic data, indicates that diaspore in bauxite and clay deposits may have formed at atmospheric pressures and temperatures, a familiar conclusion from field observations. --Auth.

1-3083. Sudo, Toshio, and M. Matsuoka. ARTIFICIAL CRYSTALLIZATION OF VOLCANIC GLASS TO SODALITE AND A ZEOLITE STRUCTURE: Geochim. et Cosmochim. Acta, v. 17, no. 1/2, p. 1-5, diag., graphs, table, Aug. 1959, 3 refs.

By digesting glassy tuff with alkali solutions on the water-bath, the writers obtained sodalite and a zeolitic material. Studying in detail the products obtained by the reactions of glassy tuff with NaCl and NaOH solutions in various concentrations, the writers confirmed the conditions being favorable for crystallization of these materials. As a result of this, the writers further confirmed that the longer the tuff was warmed in more concentrated solutions, the more sodalite was produced, and crystallization of a zeolitic material is favorable in cases of lower concentrations of these solutions. NaOH solution seems to behave as a catalyst for the crystallization. --Auth.

1-3084. Coombs, D.S., A.J. Ellis, W.S. Fyfe, and A.M. Taylor. THE ZEOLITE FACIES, WITH COMMENTS ON THE INTERPRETATION OF HYDROTHERMAL SYNTHESES: Geochim. et Cosmochim. Acta, v. 17, no. 1/2, p. 53-107, 18 figs. incl. map, diags., graphs, 18 tables, Aug. 1959, 150 refs.

Field, petrographic, and experimental evidence is presented on assemblages involving Ca-Al and Na-Al silicates, warranting recognition of a zeolite facies. This facies largely bridges the gap between diagenesis and conventional metamorphism. The metamorphic geology of the New Zealand geosyncline is reviewed, and zeolite facies rocks are shown to be of regional extent. They include lower grade heulandite-analcime-quartz assemblages and higher grade laumontite-albite-quartz in tuffs and volcanic greywackes. Thomsonite is found in basic igneous rocks of the Otama complex. Separating the zeolitic rocks from typical greenschists is a broad belt with quartz-prehnite and quartz-pumpellyite assemblages.

The significance of zeolite sequences in amygdales is often a matter of doubt, but zeolite occurrences in sedimentary rocks, active thermal areas, alkaline igneous rocks, and miscellaneous joints and cavities lend some support to 2 broad generalizations: firstly, the water content relative to $(Ca, Na_2)O \cdot Al_2O_3$ tends to increase for lower temperatures of formation in accordance with theoretical expectations based on entropy; secondly, zeolites can be divided into 3 groups based on silica content: those whose occurrence is favored by an environment supersaturated in silica, those that often coexist with quartz, and those favored by silica-deficient environments.

The common species in the Wairakei thermal area are mordenite and wairakite, both of which are readily synthesized, whereas laumontite and heulandite, typical of regional metamorphism, are not readily synthesized. This fact, together with the profound influence of starting materials on reaction products in hydrothermal syntheses, emphasizes the lack of equilibrium in our experiments, even in runs of 30 days. The field of high-silica phases such as mordenite is extended when the silica activity is higher than that of quartz. The effect of differing $\underline{P}$ load and $\underline{P}$ H_2O on important transitions such as analcime + quartz = albite + water is explored on theoretical grounds. Experiments place the reaction temperature at 280°C. at 1,000 bars water pressure, but the equilibrium temperature may be much lower. Preliminary solubility work indicates a reaction temperature near 200°C. at saturated water vapor pressure. Under conditions where load pressure equals 3 times the water pressure the temperature may be lowered by about 200°C. The upper limit of the zeolite facies is believed to be about 300°C., when water and load pressures are approximately equal.

Fields of synthesis are given for the following: analcime-wairakite series, Na-Ca mordenite series, epistilbite, prehnite, and an unidentified phase Z. Phillipsite was synthesized from chabazite. The upper limit of thomsonite is considered to be near 300°C. where it breaks down to anorthite.

The range of composition and density of naturally-occurring zeolites is reviewed. New analyses and optical data are given for heulandite from Cape Blomidon, Nova Scotia, and for prehnite from Prospect Quarry, New South Wales. --Auth.

1-3085. Goldberg, Edward D. X-RAY TECHNIQUES FOR PROBING THE LUNAR SURFACE: Lunar & Planetary Explor. Colloquium, Proc., v. 1, no. 5, p. 19-21, March 1959.

An instrument package which will permit identification of moon-surface materials is desired. Three techniques appear reasonable: infrared absorption or reflection analysis, microscopic analysis using visible light, and X-ray diffraction analysis. The last of these offers the greatest opportunity for designing a versatile package giving the most sensitive results with the fewest disadvantages. --M. Russell.

1-3086. Turekian, K.K. THE TERRESTRIAL ECONOMY OF HELIUM AND ARGON: Geochim. et Cosmochim. Acta, v. 17, no. 1/2, p. 37-43, 4 tables, Aug. 1959, 17 refs.

Using a model of continuous degassing of the earth and recent data on the chemical composition of chondritic meteorites, a "degassing constant," α, is determined from the Ar-40 economy of the earth. The value of α, assuming an earth 4.55×10^9 years old, is 2.81×10^{-11} $year^{-1}$. On the assumption that α is constant for all volatiles escaping from the earth, the He economy of the earth is discussed. On the same premise the primordial water concentration of the solid earth, devoid of a hydrosphere, is determined to be 2,300 p.p.m. which compares favorably with 2,650 p.p.m. for chondrites. The small size of α indicates that the rate of water release from the earth has been sensibly constant over the past 4.55×10^9 years. --Auth.

1-3087. Urey, H.C., and Toshiko Mayeda. THE METALLIC PARTICLES OF SOME CHONDRITES: Geochim. et Cosmochim. Acta, v. 17, no. 1/2, p. 113-124, 19 illus., Aug. 1959, 6 refs.

A study of the metal particles of 11 chondrites and 1 achondrite of a unique kind has been made. It is concluded that the metal particles secured their principal characteristics by a slowly cooling process in a primary object. This body was broken up and the materials reaccumulated into a secondary object. Reheating to about 500°C. occurred during the breakup process. This took place in their history starting some 4.5 Æ ago. A few glass chondrules may owe their origin to heating to high temperatures in very limited volumes.

Abee is an achondrite containing substantial amounts of Fe and troilite. It is not a conglomerate and may be a stony Fe in which the mixtures of metal and silicate are on a microscopic scale. No evidence of reheating of this object has been found. Crystalline silicates are suspended in the metallic phase, indicating that the body was formed in a low gravitational field.

The observed corrosion in all meteorites studied is probably of terrestrial origin. --Auth. concl.

1-3088. Hoffman, J.H., and Alfred O. Nier. THE COSMOGENIC He^3 AND He^4 DISTRIBUTION IN THE METEORITE CARBO: Geochim. et Cosmochim. Acta, v. 17, no. 1/2, p. 32-36, 4 figs. incl. graphs, table, Aug. 1959, 6 refs.

The cosmogenic He^3 and He^4 distribution in a cross section of the Fe meteorite, Carbo, has been made with a mass spectrometer. The He^3/He^4 ratio is approximately constant throughout most of the cross section and has a value of 0.239. The amount of He^3 varies between the approximate limits of 3.2 and 4.6×10^{-6} std. cm. ^{3}/g. of meteorite. Contours of constant He^3 and He^4 were plotted. These are open curves indicating the meteorite was either split in half in its lifetime or eroded away on one side since its fall to earth. --Auth.

1-3089. Ehmann, W.D., and John R. Huizenga. BISMUTH, THALLIUM AND MERCURY IN STONE METEORITES BY ACTIVATION ANALYSIS: Geochim. et Cosmochim. Acta, v. 17, no. 1/2, p. 125-135, graph, 2 tables, Aug. 1959, 19 refs.

The radiochemical procedures for the assay of Bi, Tl, and Hg in stone meteorites following neutron activation are described in detail. A Bi^{209} abundance of 2.2×10^{-9} g./g. meteorite leading to a cosmic abundance of 0.0016 (per 10^6 Si atoms) was determined from the analysis of 6 stone meteorites. A Tl^{203} abundance of 0.40×10^{-9} g./g. meteorite and a Hg^{202} abundance of 30×10^{-9} g./g. meteorite corresponding to cosmic abundances of 0.00030 and 0.023 (per 10^6 Si atoms), respectively, were determined from analysis of 5 stone meteorites. Implications of these data as pertaining to the life history of meteorites are discussed. --Auth.

1-3090. Hamaguchi, H., and R. Kuroda. SILVER CONTENT OF IGNEOUS ROCKS: Geochim. et. Cosmochim. Acta, v. 17, no. 1/2, p. 44-52, 3 graphs, 5 tables, Aug. 1959, 14 refs.

The following averages of Ag for various types of Japanese igneous rocks have been obtained (in p.p.m.): granites 0.037, granodiorites 0.050, liparites 0.049, quartz diorites and diorites 0.053, silicic andesites and andesites 0.080, basalts 0.11, diabases 0.12, gabbros 0.11, and ultramafic rocks 0.060. The crustal abundance of Ag is estimated to be 0.08 p.p.m. --Auth.

1-3091. McLaughlin, R.J.W. THE GEOCHEMISTRY OF SOME KAOLINITIC CLAYS: Geochim. et Cosmochim. Acta. v. 17, no. 1/2, p. 11-16, table, Aug. 1959, 4 refs.

The major and minor elements of 10 kaolinitic clays (kandites) are traced through the various size-fractions (sand, silt and clay). The minerals considered range from dickite through kaolinite to halloysite with also an example of b-disordered kaolinite. --Auth.

1-3092. Ichikuni, M. UNE CONSIDÉRATION SUR LA FORMATION DE L'ION SULFATE DANS LES EAUX THERMALES [A CONSIDERATION OF THE FORMATION OF THE SULFATE ION IN THERMAL WATERS]: Geochim. et Cosmochim. Acta, v. 17, no. 1/2, p. 6-10, 4 tables, Aug. 1959, 4 refs.

Given the fact that one can express the concentration of all components found in the water of the principal sources of Tamagawa, Japan as a $[Cl^-]$ + b $[SO_4{}^{2-}]$, the independence of the chloride ion from the sulfate ion is successfully established. Thus, one can affirm at least 3 types of water which constitute these sources: 1) water of magmatic origin, containing hydrochloric acid, sulfuric acid, sulfurous anhydride, but not sulfate; 2) water containing sulfuric acid, the formation of which is due to the oxidation of certain sulfur compounds which occurred not very deep in the earth; and 3) subterranean water which merely contributes to the dilution of the acid waters. --Auth. (transl. by J. Krauss).

1-3093. Allais, G., and H. Curien. MESURE DE LA TENEUR EN BORE-10 DES MINERAUX [MEASUREMENT OF THE BORON^{10} CONTENT OF MINERALS]: Geochim. et Cosmochim. Acta, v. 17, no. 1/2, p. 108-112, diag., graph, table, Aug. 1959, 7 refs.

A method of analysis of B^{10} based on its properties of thermal neutron absorption is described. The precision of the method is of the order of 2%, but its operating procedure is simple and rapid. Furthermore, the isotopic ratio B^{10}/B^{11} has been established in 5 minerals of diverse origin. --Auth. (transl. by J. Krauss).

1-3094. Chow, Tsaihwa J., and Claire C. Patterson. LEAD ISOTOPES IN MANGANESE NODULES: Geochim. et Cosmochim. Acta, v. 17, no. 1/2, p. 21-31, 3 figs. incl. map, 2 tables, Aug. 1959, 15 refs.; also pub. as: California Inst. Technology, Div. Geol. Sci., Contr. no. 899.

The isotopic compositions of leads which were isolated from Mn nodules of the Atlantic and the Pacific oceans were determined. The Atlantic leads were more radiogenic than those of the Pacific. The Pacific samples showed a trend of increasing radiogenic leads from the NW. toward the SE. Pacific. The relationship between the collecting sites and the isotopic compositions of leads can be used to trace the circulation patterns of deep-water masses. The oceanic leads originated from rock systems whose U and Pb contents have differentiated at various times appreciably later than 4·5 x 10^9 years. --Auth.

1-3095. Skropyshev, A.V. GASEOUS-LIQUID INCLUSIONS IN CRYSTALS OF ICELAND SPAR. Translated by V.P. Sokoloff: Internat. Geology Rev., v. 1, no. 9, p. 1-11, 4 illus., 7 tables, Sept. 1959, 10 refs.

Study of inclusions in Iceland spar crystals might furnish important data on the composition of mother liquors, temperature of mineral formation, and, for industrial purposes, insight into the problem of optical defects in crystals. Two basic types of inclusion were distinguished according to time of formation and orientation, relative to the host crystal: primary inclusions (7 types were recognized), originated as solution particles captured and oriented during crystal formation; secondary inclusions (including 4 types) indicate solution entrance through fissures or adherence to twinning surfaces. Inclusions vary in size from near-submicroscopic to 30 mm., and in shape, from pronounced irrgularity to crystalline. Temperatures of mineral formation, established at several sites, ranged from a minimum of 27° to as high as 200°C. Generally, crystals of superior optical quality were formed at relatively high temperatures. Analysis of the gaseous-liquid contents shows from 1 to not over 8% of the volume is occupied by gas. Mineral-forming solutions are highly concentrated (386 g. per mm.), weakly alkaline, and composed of chlorides and other salts. --D. D. Fisher.

8. MINERALOGY AND CRYSTALLOGRAPHY

See also: Geochemistry 1-3064, 1-3095.

1-3096. Dana, James D. DANA'S MANUAL OF MINERALOGY. Revised by Cornelius S. Hurlbut, Jr.: 17th ed., 609 p., 634 figs. incl. illus. (2 col.), charts, diags., graphs, tables, New York, John Wiley & Sons, 1959, refs.

The *Manual of Mineralogy* is a college textbook for a beginning course in mineralogy. The chapter on crystallography includes a discussion of the 32 crystal classes, the use of the stereographic projection, calculation of axial ratios and a brief treatment of X-ray crystallography. The important physical properties are considered but a discussion of optical properties is omitted.

The chapter on chemical mineralogy is largely a discussion of the crystal chemistry of minerals. Included are types of bonding, the coordination principle, radius ratio, electrostatic valency, compositional variation, solid solution, exsolution and pseudomorphs. Blowpipe tests are considered, but in less detail than in earlier editions.

The major portion of the book on descriptive mineralogy considers, in some detail, the properties, occurrences and uses of approximately 200 mineral species. Prefacing each mineral group is a brief discussion of the crystal chemistry of the group. Short chapters are included on the occurrence and association of minerals and on mineral uses.

At the back of the book are determinative tables enabling one to identify a mineral by means of its physical properties. The subject index is followed by a mineral index which includes over 400 mineral names. Following each of the mineral names listed in the index is given the chemical composition, crystal system, specific gravity, and hardness. --E. N. Shaine.

1-3097. Kuellmer, Frederick J. X-RAY INTENSITY MEASUREMENTS ON PERTHITIC MATERIALS. I. THEORETICAL CONSIDERATIONS: Jour. Geology, v. 67, no. 6, p. 648-660, 4 figs., Nov. 1959, 35 refs.

With the use of well-established relations between integrated intensities, integral breadths, and composition, a method is outlined by means of which it appears possible to determine the relative structural states of many perthitic alkali feldspars with powder X-ray diffractometry. The basic relation for this procedure is:

$$\frac{\int I\,(2\theta)_{o}\,d\,(2\theta)}{\int I\,(2\theta)_{a}\,d\,(2\theta)} = \frac{I_o\beta_o}{I_a\beta_a} = k\left(\frac{x_o}{x_a}\right),$$

where the subscripts o and a refer to the orthoclase-rich and albite-rich phases of the perthite: $\int I(2\theta)\,d\,(2\theta)$ is the integrated intensity of 1 phase; I is the maximum intensity; β is the integral breadth; x is the weight fraction of 1 component; and k is a constant. For a perthitic alkali feldspar whose component phases are near to the end-member composition, the line-broadening ratio (β_a/β_o) of the $(\bar{2}01)$ reflections decreases as the orthoclase-molecule content decreases and as the temperature-structural state of the feldspar decreases. --Auth.

1-3098. Ghose, Subrata, and Erwin Hellner. THE CRYSTAL STRUCTURE OF GRUNERITE AND OBSERVATIONS ON THE Mg-Fe DISTRIBUTION: Jour. Geology, v. 67, no. 6, p. 691-701, 2 figs., 4 tables, Nov. 1959, 8 refs.

To determine the nature of the Mg-Fe distribution in the 4 different metal positions in ferromagnesian amphiboles, the crystal structure of a grunerite, with about 30 mole % of the Mg component, has been determined and refined by the least-squares method. It is found that Mg and Fe are randomly distributed in 3 metal positions, while the fourth metal position is mainly occupied by Fe atoms. --Auth.

1-3099. Rumanova, I.M., and T.I. Skipetrova. THE CRYSTAL STRUCTURE OF LAWSONITE: Akad. Nauk SSSR, Proc., Physics Secs., in translation, v. 4, no. 1, p. 20-23, 2 figs., table, Jan.-Feb. 1959, 6 refs.

The structure of lawsonite $CaAl_2[Si_2O_7](OH)_2 \cdot H_2O$ was determined as part of a program of investigation on silicate structures. Results of previous studies on this mineral are discussed. In the analysis conducted by the authors, "X-ray rotation photographs about a, b, and c were taken using MoK_α radiation, and also moving films of the layer lines obtained by rotation about b (0, 1, 2) and a (0); the intensities of the reflections were estimated visually by the degree of blackening. The cell parameters found correspond well with the earlier results: a=8.83 Å, b=5.80 Å, c=13.20 Å." Certain results showed that the diffraction group is Cc--, and further experimentation indicated the space group of lawsonite to be Ccmm= D_{2h}^{17}. The authors discuss other means of analysis by which they arrived at a structure for this mineral. The coordinates of the atoms in the asymmetric unit of lawsonite are given in tabular form. A diagram showing a projection of the structure of lawsonite on the xz plane in coordination polyhedra is also included. Cleavage in lawsonite and its relation to the structure is discussed. --L. M. Dane.

1-3100. Mokeeva, V.I. THE CRYSTAL STRUCTURE OF SKLODOWSKITE: Akad. Nauk SSSR, Proc., Physics Secs., in translation, v. 4, no. 1, p. 27-29, illus., diag., table, Jan.-Feb. 1959, 4 refs.

The sklodowskite structure may be considered as composed of layers of $[(UO_2)_2\,(SiO_4)_2]^{-4}$, analogous to the layers in the structure of uranofane, but displaced parallel to each other by half the c spacing. The layers are linked to one another through the Mg atoms. If the charge on the layer is compensated by the valence of the Mg, one of the O atoms of the layer must be a hydroxyl (OH). Clearly this will be one of the O atoms of the uranyl group O_U1 (there being no H_2O molecule adjacent to it) although the possibility of a different choice is not excluded; thus the American workers preferred to leave the uranyl group UO_2, and to introduce an additional H into part of the H_2O, making the corresponding particles hydroxonium ions. According to the structure proposed by us, the formula of sklodowskite is $MgU_2O_2(OH)_2[SiO_4]_2 4H_2O$. --From auth.

1-3101. Leskevich, I.E. CRYSTALS OF QUARTZ IN COALS: Akad. Nauk SSSR, Proc., Physics Secs., in translation, v. 4, no. 1, p. 24-26, 2 illus., diag., Jan.-Feb. 1959, 12 refs.

Small regular crystals of quartz are found among authigenous mineral inclusions in Tertiary coals of the Dnepr brown coal basin, and in the low-carbon coal deposits of the Don basin, U. S. S. R. Quartz crystal content of brown coals may be 30% or more by weight of the coal. The large number of crystals gives the coal a characteristic shiny glittering appearance. The simple form of the crystals shows that the prisms are hexagonal (m); the development of the faces of each rhombohedron is different. All crystals are transparent and colorless, and only occasionally are inclusions of organic material found. There are no marks on the faces, and no signs of compression were observed.

The following conclusions may be drawn from the article: 1) Quartz crystals in coals are syngenetic formations. 2) The organic medium is favorable to the genesis and growth of colorless quartz crystals if the behavior of the solution is regulated. 3) The organic medium provided favorable conditions for the concentration of solutions of silicic acid, and for their saturation, as is evidenced by the large number of crystallization centers in the carboniferous layer. 4) The conditions of temperature and pressure could be regulated by biochemical processes and could correspond to conditions existing on the surface of the earth. --A. C. Sangree and auth. concl.

1-3102. Gruner, John W. THE DECOMPOSITION OF ILMENITE: Econ. Geology, v. 54, no. 7, p. 1315-1316, Nov. 1959, 3 refs.

Experiments are briefly described in which ilmenite decomposes into TiO_2 and pyrite by exposing it to H_2S at temperatures in the range of 300°C. These experiments may point up field occurrences such as the U ore of the Pronto mine, Blind River district, Ontario, where ilmenite has evidently decomposed to rutile or anatase and subsequently reacted with UO_2 to form brannerite. Attempts to form brannerite at 220°C. resulted in the formation of uraninite and anatase. Evidently brannerite forms only at higher temperatures and pressures. --J. A. Chamberlain.

1-3103. Wilkerson, Albert S., and Staff Members of the New Jersey Geological Survey. MINERALS OF NEW JERSEY: Geol. Soc. New Jersey, Rept. no. 1, 51 p., fold. col. geol. map, 1959, 26 refs.

An up-to-date listing of minerals occurring in New Jersey is given, together with the major localities of each mineral within the state. The catalog (p. 5-16) lists over 300 mineral species and varieties including the somewhat recently discovered minerals doverite and roweite. An attempt has been made to eliminate species and varieties discredited since publication of previous lists of New Jersey minerals. Mineral formulae are not stated.

Lists and articles which follow the catalog deal with: minerals first found at Franklin; other minerals found at Franklin; zeolite minerals of New Jersey; other minerals found in New Jersey trap rocks; radioactive minerals of New Jersey; minerals of the Coastal Plain; Cape May diamonds; economic minerals of New Jersey; incorrect names, usages, and identifications as they apply to the minerals of New Jersey; classification of minerals; rockhound rules; organizations; geological and mineralogical exhibits; bibliography; geologic map of New Jersey. --L. M. Dane.

1-3104. Northrop, Stuart A. MINERALS OF NEW MEXICO: rev. ed., 665 p., map (in pocket) scale 1:1,000,000, Albuquerque, New Mexico, University of New Mexico Press, 1959, 1,300 refs.

About 320 species and 80 additional varieties of minerals were included in the first edition of this book (1942, reprinted 1944). The current revision includes 440 species and 130 varieties. An addendum cites 20 more minerals that were recorded from the state while the book was in preparation during 1956-57 and in press during 1958-59.

Included in Pt. 1, the Introduction (p. 1-93), is a summary of highlights in the history of New Mexico mineralogy and mining. This includes sections on the prehistoric utilization of minerals and a chronological résumé of the records of Spanish explorers from 1535 to 1800 and then of American explorers, prospectors, miners, and geologists to 1957. Summary lists of early records are given for certain years from 1535 to 1904. Changes in name or status of certain minerals and a number of erroneous and discredited citations are reviewed. Following this is a chronological résumé of minerals discovered in New Mexico each year since 1925.

There is a summary of unpublished records of occurrence of 167 minerals from 92 localities contributed by 65 persons. Other lists include one of minerals which have been quantitatively analyzed, of museum specimens and the localities furnishing these, of fluorescent minerals, and of radioactive minerals. Finally, there is a list of 175 minerals which are outstanding for one reason or another. This is followed by a comprehensive review of some of the economic aspects of the state's mineral industry. This section includes a general survey, comparison with other states, national rankings of productive values, changes in trend of exploitation, total all-time value of production of individual commodities, résumés of fuels, metals, and nonmetals, etc.

In Pt. 2 (p. 95-567), descriptions and records of occurrence are given. Minerals are arranged alphabetically, and a complete system of cross-referencing has been employed, so that only the name of the mineral, whether species or variety, need be known to find it readily. A summary of the composition and physical properties is given for each mineral and then the records of occurrence, county by county, and district by district. Expanded treatments are given for meteorites and turquoise.

Pt. 3 (p. 569-596) is an annotated list of districts, subdistricts, camps, synonyms, variant spellings, etc., together with notes on location, references to topographic maps, etc. A bibliography (p. 597-665) contains 1,300 titles. A large 2-color map showing the location of 177 mining districts is in the pocket. --Auth.

9. IGNEOUS AND METAMORPHIC PETROLOGY

See also: Geochemistry 1-3068, 1-3074, 1-3076, 1-3077, 1-3084; Mineral Deposits 1-3142; Fuels 1-3166.

1-3105. Woodland, Mary Vogt. DATA OF ROCK ANALYSES - VI. BIBLIOGRAPHY AND INDEX OF ROCK ANALYSES IN THE PERIODICAL AND SERIAL LITERATURE OF SCOTLAND: Geochim. et Cosmochim. Acta, v. 17, no. 1/2, p. 136-147, Aug. 1959.

Pt. VI includes a list of 14 periodicals and serials published in Scotland, an annotated bibliography of 84 references taken from 5 of these publications between 1914 and 1953, a geographic index to the 11 countries or areas represented, and a rock-name index to the 397 analyses contained in the references. In the geographic index, Scotland is subdivided into counties.

Pts. I-V of the Data of Rock Analyses series dealt with Africa, New Zealand, Iceland, and Australia. Pts. IV and V were listed as GeoScience Abstracts 1-203, 1-1244. --A. C. Sangree.

1-3106. Osborn, E. F. ROLE OF OXYGEN PRESSURE IN THE CRYSTALLIZATION AND DIFFERENTIATION OF BASALTIC MAGMA: Am. Jour. Sci., v. 257, no. 9, p. 609-647, 14 figs. incl. diags., graphs, 4 tables, Nov. 1959, 24 refs.; also pub. as: Pennsylvania State Univ., College of Mineral Industries, Contr. No. 58-78.

Two types of crystallization paths in iron oxide systems are illustrated by describing equilibrium crystallization in the fayalite field of the system FeO-

Fe_2O_3-SiO_2. In one type where total composition of the mixture remains constant, composition of the liquid changes along a path leading to a boundary curve and thence to an invariant point. In the other type oxygen partial pressure remains constant causing the liquid of the crystallizing mixture to follow an oxygen isobaric line on the liquidus surface. In this second type of crystallization the oxygen content of the mixture changes.

These principles are extended into an examination of crystallization phenomena in the quaternary system MgO-FeO-Fe_2O_3-SiO_2. In this system occurrence of extensive solid solution in olivine, pyroxene, and magnetite structures along with incongruent melting of pyroxene necessitates consideration of fractional as well as equilibrium crystallization. It is shown that with fractional crystallization at constant total composition (Type I) the liquid moves to the magnetite (magnesioferrite) surface and thence down this surface, continuously decreasing in amount and increasing in iron oxide content. With magnetite as one of the crystallizing phases, oxygen pressure decreases. Liquids take the same general direction of composition change as they do during fractional crystallization in the simpler system, MgO-FeO-SiO_2. Initial FeO/Fe_2O_3 ratio does not affect direction of movement of liquid after the magnetite surface is reached. With fractional crystallization at constant oxygen partial pressure (Type II), the direction of movement of liquid is very different. Because the liquid must remain on an isobaric surface, change in composition of the liquid is in the direction of increasing silica and decreasing iron oxide content as soon as magnetite begins to crystallize. The liquid moves along the magnetite boundary terminating at the pyroxene-magnetite-silica univariant line, where the liquid completes its crystallization without further change of composition just as if it had reached a eutectic point. For mixtures analogous to basalt composition, a small net increase in oxygen content is realized during the crystallization. If oxygen pressure increases during fractional crystallization, the liquid moves to even higher silica and lower iron oxide end points than under conditions of constant oxygen pressure. Thus the trend of change of liquid composition toward higher iron oxide contents during fractional crystallization of Type I shifts progressively to one of decreasing iron oxide content and increasing silica as the rate of decrease in oxygen pressure required in Type I crystallization becomes less and approaches the condition of constant or increasing oxygen pressure. The ratio of iron oxide to iron oxide plus magnesia in the fractionating liquid rises steeply with increasing silica content in Type I crystallization, and rises gently in Type II, for mixtures simulating basalt compositions.

Analyses applicable to igneous rocks are plotted for comparison with curves for fractionating liquids in the system MgO-FeO-Fe_2O_3-SiO_2. The iron oxide-magnesia trends for average tholeiitic basalts and Skaergaard liquids are of the same nature as those for liquids of Type I crystallization, whereas the basalt-andesite-dacite-rhyolite series exhibits trends of the nature of Type II crystallization. An example of the latter is the Cascade lava series. Basaltic magmas of the non-orogenic regions typically crystallize with total composition remaining essentially constant. Basaltic magmas entering the orogenic belts evidently crystallize with oxygen pressure remaining approximately constant. That this is true is further borne out by plotting subtraction diagrams. Where crystallization is of Type I, the FeO and Fe_2O_3 curves have a continuous slope, whereas with crystallization of Type II the curves for the 2 iron oxides have a discontinuity in slope because of addition of oxygen to the mixture during crystallization. The subtraction diagrams further suggest that high alumina basalts develop from tholeiitic olivine basalt by fractional crystallization under conditions such that plagioclase is delayed in separating from the liquid.

The tendency for oxygen pressure to decrease at a slower rate, or remain about constant, or actually to increase during crystallization of basaltic magma entering orogenic belts instead of decreasing as in Type I crystallization, may be the result of higher water contents of orogenic magmas coupled with their habit of accumulating in reservoirs where with slow cooling and fractional crystallization water pressure increases during crystallization. Liquids escaping from the reservoirs extrude as calc-alkali series of lavas and ash while those remaining below the surface cool as granodiorite and related plutonic rocks. The complementary crystal fraction is represented by peridotites and serpentinites. --Auth.

1-3107. Wyllie, P.J., and O. Frank Tuttle. EFFECT OF CARBON DIOXIDE ON THE MELTING OF GRANITE AND FELDSPARS: Am. Jour. Sci., v. 257, no. 9, p. 648-655, 2 graphs, 2 tables, Nov. 1959, 12 refs.; also pub. as: Pennsylvania State Univ., College of Mineral Industries, Contr. No. 58-66.

Unlike water vapor and F, carbon dioxide under pressure has little or no effect on the rates of melting or crystallization of granite or alkali feldspars, and the melting temperatures are apparently unaffected except insofar as pressure per se raises the temperature of melting. The melting temperature of granite in the presence of a mixture of carbon dioxide and water vapor at a fixed total pressure is raised if the proportion of carbon dioxide in the vapor is increased, indicating that carbon dioxide is less soluble in granitic liquids than is water. Although the solubility of carbon dioxide in granitic liquids is too small to be determined directly by the techniques used, any appreciable solubility would produce a measurable lowering of the melting temperature. It is suggested that the solution of carbon dioxide in silicate liquids depends upon the availability of cations which are not structurally bound to the silicate network of the liquid and are therefore available for carbonate formation in the liquid. --Auth.

1-3108. Korzhinsky, D.S. THE ADVANCING WAVE OF ACIDIC COMPONENTS IN ASCENDING SOLUTIONS AND HYDROTHERMAL ACID-BASE DIFFERENTIATION: Geochim. et Cosmochim. Acta. v, 17, no. 1/2, p. 17-20, Aug. 1959, 10 refs.

The acidity of ascending solutions changes regularly in the course of postmagmatic processes as is shown by geological evidence. Toward the end of the crystallization of granitic magmas the acidity of the residual solutions increases, which results in the leaching out of rocks which the solutions encounter. The acidity then decreases, which causes the precipitation of bases, including ore, from the solutions.

The leaching process may affect a large volume of rock, while the succeeding precipitation of the bases is substantially confined to fissures, so that fissure vein deposits are formed within the leached rocks.

The regularities in the regimen of acidity of postmagmatic solutions and particularly the close spatial relationship of leaching and successive precipitation cannot be explained by the existing hypotheses.

According to the writer's hypothesis, the postmagmatic leaching and subsequent precipitation depend in essence, not on the fractionation of the solutions in the magma chamber, but on the passage of an "advancing wave of acidic components" along the flow of magmatogeneous solutions...

The wave of acidity generated by the crystallization of magma attains maximum acidity at some point in its ascent and then gradually fades, owing to the diffusion of the acidic components into the wallrocks and the fixing of these components by the replacement reactions. Owing to the flow of the solutions, the passing of the acidity wave results in the general displacement of the leached components in the direction of flow. Therefore in rocks altered by the flow of ascending solutions the following vertical zoning should evolve (from bottom to top):

1) The zone of increasing acidity of the advancing wave. The leaching out of the rocks increases upwards, the subsequent precipitation being insignificant or even almost lacking. This is essentially the zone of autometasomatic alteration of the magmatic rocks.

2) The zone of maximum leaching. Leaching is accompanied by subsequent precipitation, mainly of weak bases (minerals of Al, Fe, Ti, etc.). On the average, in this zone the leaching out of bases sharply predominates over their precipitation.

3) The zone of fading acidity of the advancing wave. Leaching decreases upwards whereas the subsequent precipitation of bases increases. In telethermal ore veins (carbonate, fluoritic, baritic) the precipitation sharply predominates over the preceding leaching. The latter may even be absent.

The suggested syphothesis is, of course, only a tentative rough scheme depicting a very complicated natural process. --Auth.

1-3109. de Waard, D. ANORTHITE CONTENT OF PLAGIOCLASE IN BASIC AND PELITIC CRYSTALLINE SCHISTS AS RELATED TO METAMORPHIC ZONING IN THE USU MASSIF, TIMOR: Am. Jour. Sci., v. 257, no. 8, p. 553-562, 6 figs. incl. map, diags., graphs, Oct. 1959, 12 refs.

Systematic sampling of basic and pelitic crystalline schists in the Usu massif has yielded information relating to the anorthite content of plagioclase in the greenschist and in the lower-grade portion of the almandine amphibolite facies. Frequency curves in which frequency of occurrence is plotted against anorthite content have been constructed for basic and for pelitic schists.

1) The frequency of occurrence of plagioclase between An_5 and An_{20} in basic rocks was found to be remarkably low, in contrast with the high frequencies for plagioclases on both sides of this interval. In the field the values of the interval An_5 to An_{20} occupy a relatively narrow zone. During metamorphism the transition from An_5 to An_{20} apparently took place in a narrow pressure-temperature field.

2) The general shape of the frequency curve for pelitic rocks has the same characteristics as that for basic rocks. Differences appear in values between An_{10} and An_{30-35}, which are generally higher, and in values above An_{30-35}, which are commonly lower than those in basic rocks.

3) The An_{10} boundary between the greenschist facies and the almandine amphibolite facies as advocated in the facies classification of Fyfe, Turner and Verhoogen proves to be a sharp one in the Usu massif. The abrupt transition around An_{10} characterizes the facies boundary which can be traced in the field in great detail. For the determination of the An_{10} isograd both basic and pelitic rocks can be used, as the 2 frequency curves intersect in this point.

4) The An_{30} isograd used by some writers as a facies boundary appears as an arbitrary point on a smooth part of the curve and is, therefore, far less distinctive than the An_{10} isograd. --Auth.

1-3110. Roddick, J.A., and J.E. Armstrong. RELICT DIKES IN THE COAST MOUNTAINS NEAR VANCOUVER, B.C.: Jour. Geology, v. 67, no. 6, p. 603-613, 15 illus. on 2 pls., 3 figs., Nov. 1959, 9 refs.

Many of the dikes in this area exhibit conflicting age relations with the plutonic rocks which contain them. Some of the dikes show clear evidence of having been replaced by the same plutonic rocks they evidently cut. Conflicting evidence is also provided by the associated extrusives, which, although they rest on and contain boulders of, plutonic rock, are dioritized and locally intruded by this same rock. The writers suggest that these dikes are essentially contemporaneous with the formation and evolution of the plutonic rock and that therefore the plutonic rock, while it was evolving by metasomatism and recrystallization, was capable of sustaining fractures. It can be demonstrated that breaks in the plutonic rock, either faults or joints, were present after the intrusion of some of the dikes, and that these breaks have since totally healed by recrystallization. For the study of plutonic rocks the dikes described afford a useful tool. --Auth.

1-3111. Ward, Richard F. PETROLOGY AND METAMORPHISM OF THE WILMINGTON COMPLEX, DELAWARE, PENNSYLVANIA, AND MARYLAND: Geol. Soc. America, Bull., v. 70, no. 11, p. 1425-1458, 7 figs. incl. 3 maps, diags., fold. pl. (map), Nov. 1959, 57 refs.

The Wilmington complex occupies about 100 sq. mi. in Delaware and adjacent Pennsylvania and Maryland and is bordered by the Wissahickon formation (lower Paleozoic?) and the Port Deposit granodiorite. Its southern edge is covered by Coastal Plain sediments. It consists of a banded gneiss comprising mafic bands of calcic plagioclase, hypersthene, augite, and commonly hornblende and thick felsic bands of quartz and andesine with minor pyroxene. In the central portion the gneiss has been invaded by a granite, probably metasomatic, consisting of orthoclase, oligoclase-andesine, biotite, and pyroxene. To the SW. the banded gneiss grades into amphibolites. Amphibolites near the gneiss contain calcic plagioclase, hornblende, and traces of hypersthene. Those farther away are hypersthene-free, and the plagioclase is replaced in part by epidote. Small bodies of amphibolite within the adjacent schist show similar characteristics.

Veins of granite, apparently related to the Port Deposit granodiorite, intrude the southwestern part of the complex. A coarse-grained undeformed gabbro stock has intruded the gneiss N. of Wilmington; a similar body of gabbro occurs as a group of low hills surrounded by Coastal Plain sediments.

The relationship between the chemical composition of the rocks and the mineral phases present indicates that the central granite body and the banded gneiss crystallized or recrystallized under granulite-facies conditions. The amphibolite near the gneiss represents upper almandine amphibolite facies (probably almandine-sillimanite subfacies), and the more distant amphibolites, having undergone greater stress, probably represent the almandine-diopside-hornblende subfacies. The complex is probably along the axis of most intense metamorphism of the Appalachian(?) revolution.

Structurally, the complex is characterized by the banding (S_1) and foliation (S_2) which are commonly, but not always, parallel. Structures in the complex generally parallel structures in the Wissahickon formation, indicating simultaneous deformation.

Recrystallization of the mafic portion of the banded gneiss was accompanied by the introduction, probably metasomatic, of the felsic material. Mafic bands may be transformed into felsic bands by the introduction of Si and Na and the removal of Ca, Fe, Mg, and Al, representing a transfer of approximately 7% material by volume. This "K-free granitization" may have a definite spatial relationship to the true granitization that produced the central granite. The origin of the mafic materials which comprise the gneiss and the amphibolites may have been 1) sedimentary (impure limestone); 2) volcanic (basaltic tuffs or flows); 3) hypabyssal (a lopolith); or 4) plutonic (a gabbro). Volcanic origin is tentatively suggested. If this is the case, the rocks may be correlative with metabasalts of nearby Cecil County, Maryland, and with the Catoctin-South Mountain metabasalts in western Maryland, both of which underlie the Glenarm series. --Auth.

1-3112. Gehman, Harry Merrill, Jr. NOTCH PEAK INTRUSIVE, MILLARD COUNTY, UTAH. GEOLOGY, PETROGENESIS, AND ECONOMIC DEPOSITS: Utah Geol. & Mineralog. Survey, Bull. 62, 50 p., 12 illus., 3 maps, 4 secs., 3 tables, Jan. 1958, 27 refs.

A porphyritic quartz monzonite body is intrusive into Cambrian limestones and shaly limestones, N. of Notch Peak, causing a slight doming of the sedimentary rocks adjacent to it. The quartz monzonite body is about 3 mi. in diameter and is generally stocklike. The contacts are steeply dipping except on the SW., where a large sill extends outward for a distance of about a mile. Other minor extensions intrude the sedimentary rocks, along with aplite dikes and sills, ranging up to 50 ft. thick. These aplite bodies vary widely in composition. The orthoclase phenocrysts of the quartz monzonite and small bodies of diopside monzonite, localized along the contact, have been produced by endomorphism. Aplite and quartz monzonite have recrystallized to form pegmatite zones of variable thickness. Crystal-lined cavities in pegmatites, and in quartz monzonite and aplite, have resulted from solution of the host rock and redeposition of silica at a lower temperature.

Metamorphic effects of the quartz monzonite stock include a widespread isochemical thermal metamorphism, a widespread silica metasomatism, and an Fe-silica metasomatism localized with W and Mo ore. Thermally metamorphosed rocks, of the amphibolite facies, are interlayered nearly horizontally with silica-metasomatized zones. The silica-bearing solutions were introduced along bedding-plane joints. The silica-metasomatized rocks are characterized by the widespread development of idocrase with grossularite, diopside, wollastonite, albite, and epidote. This mineral assemblage is of the albite-epidote amphibolite facies and represents the reaction between components originally present in the rock, activated and enriched in silica by the circulating solutions.

The general sequence of magmatic activity was intrusion of the quartz monzonite, isochemical thermal metamorphism, silica metasomatism, aplite intrusion, and Fe-silica metasomatism by the W- and Mo-bearing fluids.

W and Mo ores, of some commercial importance, have been formed in tactite bodies localized at the intersection of favorable beds with the quartz monzonite contact, aplite dikes, and joints. Au, of unknown origin, forms placer deposits in arkosic sands and gravels lying within the outcrop area of the quartz monzonite stock. --Auth.

10. SEDIMENTARY PETROLOGY

See also: Stratigraphy 1-2978; Geochemistry 1-3058, 1-3060; Fuels 1-3157.

1-3113. MacClintock, Paul. A TILL-FABRIC RACK: Jour. Geology, v. 67, no. 6, p. 709-710, diag., Nov. 1959, 2 refs.

An easily constructed till-fabric rack that is a more effective, quicker method for one or more men in making fabric analyses. --Auth.

1-3114. Vassoevich, N.B. BEDDING IN LIGHT OF SEDIMENTARY DIFFERENTIATION. Translated by P.F. Moore: Internat. Geology Rev., v. 1, no. 9, p. 59-71, diag., Sept. 1959, 18 refs.

Correlation of sediments has been hindered by a dichotomy in geologic thought; synchronous and asynchronous bed formation are considered by respective proponents to be mutually exclusive. However, in the final analysis, it can be seen that both forms of bed formation exist in nature. Two laws governing sedimentary differentiation are: 1) at any time, when in a series of deposits a mutual separation of beds occur, and these beds are not very normally juxtaposed in the spatial and temporal sequence of the products of sedimentary differentiation characteristic of the accumulations in a particular area, interruption, either changes in the sedimentary regime or changes of a catastrophic nature, must occur; 2) for migrating facies, only those sediments which succeed each other laterally can succeed each other vertically. --G. E. Denegar.

1-3115. Crook, Keith A. W. UNCONFORMITIES IN TURBIDITE SEQUENCES: Jour. Geology, v. 67, no. 6, p. 710-713, Nov. 1959, 6 refs.

Unconformities usually imply subaerial erosion. It is suggested, from submarine geological data, that turbidite sequences may contain unconformities which do not indicate subaerial erosion but are due to turbidity-current scour. Included rock fragments and derived fossils in such sequences may not indicate that the source rocks were being subaerially eroded. Criteria involved in the drawing of inferences from observational data may not be valid for both traction-current and turbidity-current deposits. --Auth.

1-3116. Heezen, Bruce C. DEEP-SEA EROSION AND UNCONFORMITIES: Jour. Geology, v. 67, no. 6, p. 713-714, Nov. 1959, 8 refs.

Although turbidity currents can erode the deep-sea floor, deep ocean currents must not be neglected in considering the origin of submarine unconformities. --Auth.

1-3117. Eagleson, P.S., and R.G. Dean. WAVE-INDUCED MOTION OF BOTTOM SEDIMENT PARTICLES: Am. Soc. Civil Engineers, Hydraulics Div., Jour., v. 85, no. HY10, pt. 1, p. 53-79, diag., 11 graphs, 2 tables, Oct. 1959, 7 refs.

Theoretical analyses are presented yielding expressions for incipient motion and net velocity of single spherical bottom sediment particles under oscillatory waves. These relationships are verified by experiment and are extended to the prediction of equilibrium relationships between local wave characteristics, bottom slope, and median particle diameter found on natural beaches. --Auth.

1-3118. Heezen, Bruce C. DYNAMIC PROCESSES OF ABYSSAL SEDIMENTATION: EROSION, TRANSPORTATION, AND DEPOSITION ON THE DEEP-SEA FLOOR: Geophys. Jour., v. 2, no. 2, p. 142-163, 1959.

The concept of a quiet, nearly motionless, and certainly currentless deep-sea floor lacking the processes of erosion so prevalent in shallower seas was well ingrained in scientific thought until discoveries of the past decade revised this serene and static picture. The new concept is a more dynamic one in which submarine landslides, raging turbidity currents, internal tides, deep-sea current scour, and submarine post-depositional solution and alteration play a part in shaping the sea floor, in disturbing and nurturing its fauna, and which produce sedimentary structures and distributions formerly thought to be the exclusive mark of shallow-water deposits. The concepts involved are still in a critical state of flux with many conflicting viewpoints as to the processes involved and their relative importance. The development of the major concepts is traced and the principal variant viewpoints are briefly reviewed. --Auth.

1-3119. Mellis, Otto. SEDIMENTATION IN THE ROMANCHE DEEP (A CONTRIBUTION TO THE EXPLANATION OF THE GENESIS OF THE DEEP-SEA SANDS IN THE ATLANTIC OCEAN). Translated by Ross Geise: Internat. Geology Rev., v. 1, no. 9, p. 50-58, map, core, 6 tables, Sept. 1959, 25 refs.

Sediments cored from the Romanche deep in the Atlantic Ocean consist of Globigerina mud containing foraminifer fragments; red clay with interbedded sand lenses; sands composed of plagioclase, pyroxene, quartz, serpentine, olivine, chlorite, and other minerals; and a "detrital Globigerina ooze." Mineralogic and paleontologic examination indicate that the need for a continental source and extended horizontal transportation in suspension streams may be exaggerated. Although the theory that these deep-sea sands are products of continental weathering deposited in the deep after some thousands of kilometers of horizontal transportation and that suspension streams play an important role as the agent of transportation, redeposition, and configuration of the deep-sea sediments, it is possible that the sands in the Romanche deep were derived, at least in part, from the middle Atlantic Ridge. Therefore, deep-sea sands can provide valuable information on the composition of the submarine ridge and the mechanism of tectonic movement. --G. E. Denegar.

1-3120. Hamilton, Edwin L. THICKNESS AND CONSOLIDATION OF DEEP-SEA SEDIMENTS: Geol. Soc. America, Bull., v. 70, no. 11, p. 1399-1424, 2 illus., 10 figs. incl. sec., graphs, 4 tables, Nov. 1959, 78 refs.

Geochemical and other calculations on the total volume of sediment that should be present in deep-sea basins, based on materials released in weathering, indicate that the average thickness of sediment solids on the ocean floor should be 1-3 km. Seismic surveys in all oceans, on the contrary, report a sediment thickness on the order of 0.1-0.5 km., but also reveal that, in many areas, the surface sediments are underlain by other layers whose elastic-wave-transmission velocities are intermediate between those of sediment and the "basaltic basement" rock of the oceanic crust.

Examination of the above problem in the light of soil-mechanics studies and recent studies of the velocity of elastic compressional waves in sediments and rocks indicates the possibility that, in many areas, the lower layers are composed of rocks formed by normal consolidation and lithification of the present types of deep-sea sediments.

Gravitational consolidation of red clay should reduce sediment pore space to values between 35 and 45% at depths in the sediment between 150 and 700 m.; between these porosities, pressure-chemical effects in the dewatered sediment should result in lithification to shale and marked increase in seismic velocity.

Gravitational consolidation of calcareous ooze should result in porosity reduction at a slower rate than in clay, but lithification of this material with age and pressure can result in marked seismic-velocity increases at or near the sediment surface; the discovery of deep-sea limestone in the form of lithified Globigerina oozes ranging in porosities from 5 to 68% and in compressional elastic-wave velocities from 1.8 to 5.5 km./sec. indicates the possible velocity variations. Various combinations of clay and calcareous material are possible and probable in many areas; high velocities under a thin cover of present-day clay deposition thus possibly represent an ancient (Cretaceous to Tertiary) layer of lithified calcareous ooze.

The present sediment thickness measured in deep-sea basins is probably the total thickness of these upper layers. If so, the thickness of all layers above the "basalt" should enter the calculation of total sediment deposited on the sea floor. A measurement of sediment thickness at any time horizon of the past or future should show about the same "anomalously thin" value for the topmost part of the slowly consolidating and lithifying sediment.

Normal, expectable deposition of sediment in many deep-sea areas, and subsequent consolidation and lithification, may explain most of the seismic discoveries in these areas and fall into line with the great geochemical balance and with the theories of soil-mechanics engineering. --Auth.

1-3121. Weyl, Peter K. PRESSURE SOLUTION AND THE FORCE OF CRYSTALLIZATION - A PHENOMENOLOGICAL THEORY: Jour. Geophys. Research, v. 64, no. 11, p. 2001-2025, 5 illus., 8 diags., 13 graphs, 2 tables, Nov. 1959, 10 refs.

The phenomena of pressure solution and the force of crystallization result from removal or deposition of mineral matter in the region of contact between the mineral grains. We assume that this transport takes place by diffusion in a solution film between the grains. The rate of transport depends on the grain size, the effective normal stress between the grains, the diffusion constant in the solution film, the film thickness, and the stress coefficient of solubility. Values of these parameters required to obtain the amount of pressure solution observed in the St. Peter sandstone are reasonable. The theory predicts an increase in pressure solution with decreasing grain size. The effect of clay films between the grains is also to increase the rate of pressure solution owing to the more rapid rate of diffusion in the clay layer relative to a single solution film between clean mineral grains. This explains how preexisting clay films in the sediment may, because of the greater rate of pressure solution, develop into stylolites. If the interstitial water is supersaturated with respect to the minerals present, precipitation in the area of contact will take place as long as the supersaturation divided by the stress coefficient of solubility is greater than the average effective normal stress between the grains. If the stress is increased above this limit, pressure solution will take place. --Auth.

1-3122. Zen, E-An. CARBONATE MINERALOGY OF THE LOWER ORDOVICIAN BURCHARDS LIMESTONE IN WEST-CENTRAL VERMONT: Am. Jour. Sci., v. 257, no. 9, p. 668-672, 3 tables, Nov. 1959, 10 refs.

The mineralogy of mottled limestones and associated dolostones of the Lower Ordovician Burchards limestone in W.-central Vermont was quantitatively studied by X-ray diffraction. The dolomitic mottled patches consist of dolomite and calcite, and the bulk chemical composition calculates out consistently to about 30% of $MgCO_3$ by weight, which is verified by wet chemical analysis. Among the mottled patches, outlines of mollusks can be discerned locally. This fact, together with the constant chemical composition of the patches, in contrast with the nearly dolomite-free limestone matrix, suggests that the patches may be recrystallized organic debris with the Mg derived locally from original high-Mg calcite. The bedded nature of the Burchards further suggests a fore reef detrital origin, which agrees with present knowledge of the paleogeography of the area during Early Ordovician time. --Auth.

1-3123. Wiseman, John D.H. THE RELATION BETWEEN PALEOTEMPERATURE AND CARBONATE IN AN EQUATORIAL ATLANTIC PILOT CORE: Jour. Geology, v. 67, no. 6, p. 685-690, 2 illus. on pl., 2 graphs, table, Nov. 1959, 18 refs.

A continuous series of 1/2-cm.-thick sections from a pilot core, collected at the top of a small knoll in the equatorial Atlantic have been investigated by a variety of methods. In 1954 the suggestion was made that in this core the carbonate content was a reflection of temperature in the upper layer of the sea. Paleotemperature measurements on the tests of Globigerinoides sacculifera are given for 33 sections. The broad relation between paleotemperatures and rates of accumulation of $CaCO_3$ supports this hypothesis. If allowance is made for probable errors, the paleotemperature measurements are not inconsistent with the hypothesis that the secondary carbonate oscillations are also a reflection of temperature change. --Auth.

11. GEOHYDROLOGY

See also: Geomorphology 1-2959; Geochemistry 1-3065.

1-3124. Leopold, Luna B. WATER RESOURCE DEVELOPMENT AND MANAGEMENT: Am. Water Works Assoc., Jour., v. 51, no. 7, p. 821-827, July 1959, ref.

The United States has nearly completed the development of its water resources and now must prepare to manage them. The amount of water occurring at depths of less than 2,500 ft. in the United States is equivalent to the total of all recharge during the last 160 years. Proper management involves an appreciation of the need for appraisals, the engineer's responsibilities, and water rights. Hydrologic considerations must become one of the bases for administrative action. --M. Russell.

1-3125. Miller, Lynn M. LOCATION AND EVALUATION OF GROUND WATER RESOURCES: Am. Water Works Assoc., Jour., v. 51, no. 2, p. 273-285, 2 maps, 6 secs., 4 graphs, table, Feb. 1959, 3 refs.

Evaluation of geology and subsurface work prior to new exploration is the best basis for the selection of exploration areas in a region.

Electric resistivity and test drilling work should be coordinated to determine the best water-producing locations within an area.

Aquifer performance test work can best be evaluated by using the geological, electric resistivity, and test drilling data as a guide to the interpretation of hydraulic responses observed.

If large pumping rates are maintained over moderate test periods it is possible to analyze test data without assigning absolute values for the coefficients of transmissibility and storage, and estimate the interference of wells for the design of a well field. --Auth. summ.

1-3126. Hantush, Mahdi S. ANALYSIS OF DATA FROM PUMPING WELLS NEAR A RIVER: Jour. Geophys. Research, v. 64, no. 11, p. 1921-1932, map, 3 diags., 6 graphs, 4 tables, Nov. 1959, 7 refs.

Methods are outlined for determining the hydrologic characteristics of an aquifer draining or drained by a stream; specifically, for determining the transmissibility and storage coefficient of the aquifer and also the effective distance from a pumped well to a line in the stream bed where the water is entering or leaving the aquifer. The procedure is based on the theory of nonsteady flow toward a well steadily discharging from an infinite aquifer hydraulically connected to a fairly straight and long stretch of a stream bed. Application of these methods is illustrated by treating data from the Ingalls area in Kansas. --Auth.

1-3127. Talsma, T., and Henry C. Haskew. INVESTIGATION OF WATER-TABLE RESPONSE TO TILE DRAINS IN COMPARISON WITH THEORY: Jour. Geophys. Research, v. 64, no. 11, p. 1933-1944, 8 graphs, 5 tables, Nov. 1959, 12 refs.

An investigation of the performance of tile laterals, selected from farm drainage systems, is reported.

Useful theories of water-table response to tile lines are briefly reviewed. The field procedure used for the investigation is described.

Average hydraulic conductivity was determined from in-place measurements by the auger-hole and piezometer methods. The position of the impermeable layer was determined from textural examination of the soil and from piezometer measurements of hydraulic conductivity. The performance of laterals was investigated by simultaneous measurements of water-table height along lines at right angles to the tile and rate of discharge from the tile line.

It is concluded that Hooghoudt's theory is adequately supported where flow boundaries can be sharply defined. The field data also support Kirkham's analysis, where the physical assumption underlying this analysis is reasonably met. Field data on the rate of lowering of the water table generally support Glover's analysis, although some caution appears to be necessary when using his analysis for design in cases where there is an impermeable layer at a small distance below the tiles.

Comparison of the data with theory also shows that average values obtained of factors used in design and those indicating performance are satisfactory, though field variability is high. The adaptability of field data to theoretical simplifications is emphasized. --Auth.

1-3128. Watson, K.K. A NOTE ON THE FIELD USE OF A THEORETICALLY DERIVED INFILTRATION EQUATION: Jour. Geophys. Research, v. 64, no. 10, p. 1611-1615, graph, Oct. 1959, 10 refs.

The use of equations of the diffusion type as a means of solving certain flow problems in porous media has recently led to a convenient analytical solution for the infiltration of water into an homogenous soil of uniform initial moisture content. From the general solution a simplified infiltration equation is obtainable. This simplified equation is tested against field infiltration curves in order to investigate its possible use for the expression of these field curves with a greater degree of accuracy than has hitherto been possible with the commonly known empirical equations, in particular the Horton equation. --Auth.

1-3129. Henry, Harold R. SALT INTRUSION INTO FRESH-WATER AQUIFERS: Jour. Geophys. Research, v. 64, no. 11, p. 1911-1919, 6 diags., 5 graphs, Nov. 1959, 10 refs.

In a coastal aquifer a steady flow of fresh water toward the sea can limit the encroachment of the salt water into the aquifer. This action is treated on the assumptions that the flow is steady and 2-dimensional, that the salt and fresh water are immiscible, and that there is no fingering. Theoretical equations for the shape and location of the interface and for the boundary velocities are derived for several sets of boundary conditions.

The uncertainty of the location of the interface is circumvented by use of a hodograph plane. In addition, a complex potential is employed and related to the hodograph by conformal mapping.

Certain boundary conditions represent inversions of gravity seepage through dams for which solutions already exist. Numerical computations are also presented for a semi-infinite aquifer having a vertical seepage face and one having a horizontal seepage face. --Auth.

1-3130. Higgins, Gary H. EVALUATION OF THE GROUND-WATER CONTAMINATION HAZARD FROM UNDERGROUND NUCLEAR EXPLOSIONS: Jour. Geophys. Research, v. 64, no. 10, p. 1509-1519, graph, table, Oct. 1959, 18 refs.

Radioactivities in ground water collected at Nevada test site since the underground nuclear explosions in Operations Plumbbob and Hardtack Phase II have not been significantly above background, due to the formation of silica glass by the explosion, and the ion-exchange properties of fission products in normal earth minerals and water. The glass formed by the high shock pressures releases less than 10% of its radioactivity when leached with water, and the rock minerals crushed by the explosive forces adsorb several tens of milliequivalents of fission products per 100 g. The distribution coefficients for adsorption range from 50 to 500,000, depending on the particular fission product and mineral. A theory pertaining to the flow of activity in an ion-exchange medium is developed, and equations for application of laboratory data to field experiments are included. Some of the available distribution coefficients are tabulated from the literature on waste disposal. It is concluded from existing information that hazards arising from underground explosions in other media will not give rise to serious contamination problems. Until more experience is gained, measurements of aquifer properties should be made prior to planned explosions to determine that safe conditions exist in each particular case. --Auth.

1-3131. Brunk, Ivan W. PRECIPITATION AND THE LEVELS OF LAKES MICHIGAN AND HURON: Jour. Geophys. Research, v. 64, no. 10, p. 1591-1595, Oct. 1959, 8 refs.

A number of correlations of precipitation and the levels of lakes Michigan and Huron indicated a computable relationship and also an apparent lag between precipitation and its effect. When land-area precipitation only was considered, a correlation of lake level with 4-year precipitation data gave a correlation coefficient of 0.69. A correlation of precipitation and the difference in annual mean levels indicated a correlation coefficient of 0.68.

In order to include the effect of additional variables, a correlation of water-year precipitation on a 2-year basis and net basin supply was made. A correlation coefficient of 0.79 was obtained, and a lag between precipitation and its effect was again indicated. Monthly precipitation values were correlated with seasonal changes in level, and correlation coefficients of 0.85 and 0.81 were obtained with antecedent precipitation and the seasonal rise and antecedent precipitation and the seasonal fall in levels, respectively. Finally, it is pointed out that geological conditions in the Michigan-Huron basin provide a physical reason for the indicated lag between precipitation and its effect. --Auth.

1-3132. Van Bavel, Cornelius H.M. WATER DEFICITS AND IRRIGATION REQUIREMENTS IN THE SOUTHERN UNITED STATES: Jour. Geophys. Research, v. 64, no. 10, p. 1597-1604, 6 maps, 2 tables, Oct. 1959, 18 refs.

The frequency of exhaustion of available moisture supplies and the attendant water deficits have been determined for 9 southern states. The results are based upon estimated daily moisture balances computed for 25 years at 264 stations. Evapotranspiration was estimated with the Penman formula.

Results are given in terms of 2 parameters: storage capacity of the root zone and recurrence probability. Therefore, the values obtained have immediate practical value for a number of agrohydrological and agronomical applications. Among these are the estimation of irrigation requirements for river basins, farms, and individual fields, as well as estimation of drought hazard.

Generalized, the results indicate typical occurrence of severe drought throughout the South during the growing season. It appears that soil moisture storage capacity and recurrence frequency are more important than geographical location in determining water deficits. --Auth.

1-3133. Boyd, William L., and Josephine W. Boyd. WATER SUPPLY PROBLEMS AT POINT BARROW: Am. Water Works Assoc., Jour., v. 51, no. 7, p. 890-896, 2 illus., map, 3 tables, July 1959, 15 refs.

Renewed interest in northern areas during the last decade has reemphasized the need for good year-round sources of water for drinking as well as industrial purposes. The report deals with some of the problems at Point Barrow, northern Alaska, during 1956-1957.

Chemical determinations were carried out on fresh-water samples from lakes in the region, a major source of water supply. Ocean ice, especially "old ice" from floes over 1 year old, can serve as a limited source of water; snow is a relatively poor source. Some unsuccessful attempts have been made to utilize ground water. Drilling during recent oil explorations produced sub-permafrost water with a salinity of several thousand p. p. m. --A. C. Sangree.

1-3134. Kohout, F.A., and F.W. Meyer. HYDROLOGIC FEATURES OF THE LAKE ISTOKPOGA AND LAKE PLACID AREAS, HIGHLANDS COUNTY, FLORIDA: Florida Geol Survey, Rept. Inv. no. 19, 7 maps (4 fold.), 7 secs. (1 fold.), 19 graphs (4 fold.), 5 tables (1 fold.), 1959, 10 refs.

The hydrologic features in a 165 sq. mi. area surrounding Lake Istokopoga, were studied during the fall of 1952, to evaluate the effect of a proposed drainage canal S. of Lake Istokpoga on ground-water conditions in the Highland Ridge and Lake Istokpoga areas. An investigation of the influence of the ground-water reservoir in the Lake Placid area on the water level of the lake was started in the fall of 1955.

The Istokpoga-Indian Prairie basin is a poorly drained area of low topographic relief extending southeastward from Lake Istokpoga; its western boundary is marked by a scarp that rises to a sandy upland region of relatively great relief, referred to as the Highlands Ridge.

In the first investigation, described in Pt. 1, lithologic and hydrologic data were obtained from lines of wells and test holes. A nonartesian aquifer and several shallow artesian aquifers occur within the area of this investigation. Unconfined ground water moves toward Lake Istokpoga, except at the southern end of the lake where the ground water moves, under a low gradient, in a southeasterly direction. The movement of water in the shallow artesian aquifers is eastward from the scarp, but because of leakage through the overlying confining beds, artesian pressure decreases rapidly with increasing distance from the scarp.

The findings of the investigation indicate that the amount of ground-water pickup in a canal extending southward from Lake Istokpoga would not be excessive; also, because of evapotranspiration losses, less ground water and surface water will be picked up by a canal located at some distance from the scarp than by a canal at the base of the scarp. If the proposed canal is routed through locations where the expected altitudes of its water surface coincide with the altitudes of the water table, the canal will not intercept and drain the shallow ground water. If no excess ground-water drainage occurs because of the canal, the water table in the ridge section will not be affected, and upward leakage from the shallow artesian aquifers will not increase. Penetration of the artesian gravel aquifer which approaches the ground surface S. of State Highway 70, would pose the greatest threat to the water levels of the lakes in the ridge section. If the gravel aquifer were penetrated, the large drawdowns produced by the discharge could conceivably extend upgradient beneath the ridge and affect the water levels of the lakes.

In Pt. 2, water-table contour maps and graphs of the fluctuations of water level in Lake Placid and well 14 show that the lakes of the ridge section are visible expressions of the water table. A method of predicting the water level of Lake Placid after an extended period without rainfall makes use of curves based on ground-water recession rates. However, comparison of hydrographs of an artesian well and Lake Placid indicates that the lake level responds to pumping from the Floridan aquifer. The hydrographs show an increasing utilization of water from the artesian system, and this change in the hydrologic regimen may change the future recession rate of Lake Placid.

In rising stages, the relation between water levels in well 14 and Lake Placid is not consistent because of hydrologic conditions existing on the W. and S. sides of the lake where there is little room for additional ground-water storage because the water table is close to the land surface. The ground-water storage capacity has a direct relation to floodings in the Lake Placid basin, because as soon as the water table rises to the land surface all further recharge to the aquifer is rejected, and direct runoff to Lake Placid occurs.

Consideration is given to the quantity of water that percolates downward from Lake Placid to the Floridan aquifer. A summation, obtained by balancing the estimated quantities of inflow and outflow, the evaporation, and the change in stage of Lake Placid, indicates that the downward leakage from the lake during the first half of 1956 amounted to about 2 to 3 in. per month. --Auth.

1-3135. Gill, Harold E. GEOLOGY AND GROUND-WATER RESOURCES OF THE CAPE MAY PENINSULA, LOWER CAPE MAY COUNTY, NEW JERSEY: New Jersey, Dept. Conserv. & Econ. Develop., Div. Water Policy & Supply, Water Resources Circ. 1, 19 p., 10 maps, cross sec., graph, 1959, 2 refs.

Cape May County, a largely peninsular area extending into the ocean at the southernmost tip of New Jersey, is among the leading recreational areas in the state. Because of this, a considerable drain is placed on the county's ground-water resources during the summer months. The estimated permanent population as of July 1, 1956 was 43, 300, and the summer peak was close to 1, 000, 000. This influx is concentrated in a coastal ground-water area susceptible to salt-water encroachment.

The climate of Cape May County is mild and temperate. The average annual temperature is 53.0°F., the monthly maximum and minimum being 61.8° and 44.6°F. The average annual precipitation is 41.41 in.

Cape May County, as part of the Coastal Plain of New Jersey, is underlain by unconsolidated sediments of Quaternary, Tertiary, and Cretaceous age, mostly alternating sand and clay beds, to a depth of approximately 5,500 ft.

The principal aquifers of Cape May County, in order of present importance, are the Cohansey sand of Miocene(?) age, 2 sands in the Kirkwood formation of Miocene age, and Pleistocene sand and gravel. The largest production of ground water from any individual stratigraphic unit - an average of 10 m. g. d. (million gallons a day) in the maximum month - is derived from the Cohansey sand. The average large-capacity well in the Cohansey sand has a diameter of 12 in., a yield of 700 g. p. m. (gallons per minute), and a specific capacity of 20 g. p. m. per foot of drawdown.

Eight test holes to the bottom of the Cohansey have demonstrated the existence of a Pleistocene Delaware River channel bisecting Middle and Lower townships from Wildwood Villas to Wildwood Crest. Clay of the Kirkwood formation was penetrated at a much shallower depth than anticipated at the western edge of the county at Green Creek. From this point there is a sharp decline, both down the dip to the SE. and along the strike to the SW. The clay formed a basin in which was deposited clean gray quartz sand of the Cohansey, along the coastline and on an arc from Cape May Court House to Green Creek. In the area extending SW. from Woodbine to Green Creek, deposition began later than in other areas and was characterized by brown Fe-stained sand typical of fluvial, subaerial conditions so prevalent to the N. and W., at the Cohansey outcrop in Cumberland County.

A marked increase in salt-water encroachment into the Cohansey at the southern tip of Cape May County in the last 10 years can be attributed to the development of large-capacity wells in areas too close to the existing coastline. --Auth.

1-3136. Upson, Joseph E. RELATION OF LONG ISLAND GROUND WATER RESOURCES TO REGIONAL NEEDS: Am. Water Works Assoc., Jour., v. 51, no. 2, p. 286-300, 3 maps, sec., 4 graphs, 2 tables, Feb. 1959, 16 refs.

The general occurrence of ground water in the New York City metropolitan area, the relation of Long Island sources to the existing pattern of water use, what is known about Long Island's ground water, and some of the technical problems involved in full development of these ground-water resources are covered. Areas of low productivity are underlain by old igneous and metamorphic crystalline rocks and consolidated sedimentary rocks, areas of moderate productivity by partly consolidated sandstone and shale and some intercalated intrusive and extrusive volcanic rocks. Areas of most productivity are underlain by unconsolidated, stratified, generally permeable deposits.

The Ridgewood system constitutes New York City's water supply installations on Long Island; it has ponds, wells, and infiltration galleries along its conduit. The 4 chief water-producing units are: at the top the upper Pleistocene deposits, then the Jameco gravel, the Magothy formation, and the Lloyd sand member of the Raritan formation. In Nassau County current recharge rate is 165 m. g. d. while withdrawal is 120 m. g. d. The 5 most important technical problems are: close estimation of replenishment, portion that can be used without danger of sea-water contamination, determination of desired conditions of withdrawal, apportionment of withdrawal geologically and geographically, and production of the net artificial discharge from the ground-water system. --M. Russell.

1-3137. Norris, Stanley E. MINFORD SILT AND GROUND WATER QUALITY IN WESTERN OHIO: Am. Water Works Assoc., Jour., v. 51, no. 9, p. 1170-1174, sec., 2 tables, Sept. 1959, 5 refs.

The Minford silt, a lacustrine deposit which fills the lower part of many preglacial valleys, has long been a source of difficulty to drillers of water wells in western Ohio. However, recent investigations indicate that it may be advantageous to attempt development of water supplies from these beds because of water softening characteristics of the silt. The flow of ground water in a typical area underlain by Minford silt takes place from a permeable zone in underlying and surrounding limestone, through the Minford silt, and into overlying sand and gravel aquifers. --M. Russell.

1-3138. Holt, C. L. R., Jr. GEOLOGY AND GROUND-WATER RESOURCES OF MEDINA COUNTY, TEXAS: U.S. Geol. Survey, Water-Supply Paper 1422, 213 p., illus., 5 maps (4 in pocket), graphs (2 in pocket), logs, 12 tables, 1959, 40 refs.

The Edwards limestone of Cretaceous age is the principal water-bearing formation in Medina County and makes up the major part of a ground-water reservoir, or aquifer, which in places includes thinner limestone formations both above and below the Edwards. The Glen Rose limestone, also of Cretaceous age, yields moderate amounts of water to wells and springs in the northern part of the county. Other Cretaceous formations, including the Austin chalk, Anacacho limestone, and Escondido formation, yield only small amounts of water, and that of the Austin and Escondido is of generally inferior quality.

The Carrizo sand and the Indio formation, both of Tertiary age, supply most of the water used in the southern part of the county. The Leona formation of Quaternary age supplies water for irrigation and other farm use in areas adjacent to the main streams.

Although the regional southeastward dip of the rocks is at a low angle, the Edwards limestone, which caps the hills in the northern part of the county, is found at a depth of about 2,000 ft. below the sea level in the southern part of the county. The formations have been lowered by a series of faults. The faults, which are a part of the Balcones fault system, are mostly normal or tension faults and trend nearly parallel in a northeasterly direction. Thus, belts of rock, successively younger toward the SE., are found at the surface. Individual faults of the Balcones system are as much as 35 mi. long and have a maximum displacement of 700 ft. The Culebra anticline in eastern Medina County and western Bexar County is related to the Balcones fault system.

In all the ground-water reservoirs, water occurs under both water-table and artesian conditions. In the Edwards limestone, recharge occurs mainly where the streams cross the outcrop. The low flow of the streams is supplied by a large number of small springs that issue from the base of the Edwards limestone in the northern part of Medina County and the areas to the N., and from porous beds in the Glen Rose limestone. Most of this flow is absorbed by the Edwards limestone farther S. as the streams cross the outcrop of the Edwards near the Balcones fault zone.

The movement of water in the Edwards limestone is generally southward and eastward, but it is locally controlled by faults. Much more water probably enters and leaves the county underground through channels in the Edwards limestone than is withdrawn by wells in the county. The total withdrawal from the Edwards through wells is estimated to be about 1, 600, 000 g. p. d. The Edwards limestone supplies water for public use in Castroville and Hondo, and for an air force base at Hondo.

The sands of the Indio formation of Tertiary age supply a cannery near Natalia and numerous domestic and stock wells. Values for the coefficient of transmissibility, in places where the sand is more than 60 ft. thick, range from 10, 000 to 20, 000 g. p. d. per ft.

The Carrizo sand, which overlies the Indio formation, serves the communities of Natalia and Devine. A coefficient of transmissibility of 134, 000 g. p. d. per ft. was determined for the Carrizo at Devine. Water from the Carrizo sand and from the Leona formation is used for irrigation and for domestic and stock use. The water in the Travis Peak formation probably is highly mineralized; the water from the Glen Rose formation generally is very hard, and in most places the water is high in sulfate and dissolved solids. Water from the Edwards limestone is generally hard but of good quality in other respects, except in the southern part of the county. Two analyses of water from the Austin chalk showed moderately high concentration of sulfate; 3 samples from the Anacacho are of generally satisfactory quality; waters from the Escondido and Indio formations contain moderate to large amounts of dissolved solids and are locally high in chloride content; the water from the Carrizo sand and the Leona formation is hard but of good quality in other respects. The Leona yields high nitrate water locally.

The report contains records of 1, 099 wells and 23 springs, logs of 127 wells, periodic measurements of water levels in 54 observation wells, miscellaneous discharge measurements of 3 streams, and chemical analyses of 129 water samples obtained from wells and springs. According to the records, 895 wells are used for domestic and stock purposes, 14 are used for public supply, 35 are used for irrigation and 4 are used for industrial purposes; about 150 wells, including about 100 oil tests, are not used for water supply. --Auth.

1-3139. Bierschenk, W.H. AQUIFER CHARACTERISTICS AND GROUND-WATER MOVEMENT AT HANFORD: General Electric Co., Hanford Plutonium Works, [Pub.] HW-60601, 77 p., 2 illus., 2 maps, 12 graphs, 13 tables, June 9, 1959, 32 refs.

This work was performed under Contract No. W-31-109-Eng.-52 between the U. S. Atomic Energy Commission and the General Electric Company.

The hydraulic characteristics of Hanford [Washington] aquifers have been measured and estimated by a variety of established field methods. These include the nonequilibrium "type curve" solution, the modified nonequilibrium and Theis recovery formulas, estimations from specific capacity and cyclic fluctuation data, and the results of tracer tests. Mutually consistent results show that the permeability of the glaciofluviatile sediments ranges from about 10,000 g.p.d./ft.^{2} to more than 60,000 g.p.d. /ft.^{2}, and the permeability of the Ringold deposits ranges from about 100 to 600 g.p.d./ft.^{2}. Based on these permeability data, calculations of the average rate of ground-water flow indicate a range from a few inches per day to as much as 160 ft./day.

The hydraulic studies show that wastes which reach the water table beneath disposal sites will potentially move in a general southeastward and eastward direction some 20 mi. to the Columbia River. Average rates of ground-water flow indicate that travel along this estimated mean lateral path of ground-water contamination could conceivably be completed in an average time in the order of 180 years. Such factors as heterogeneity and anisotropy of the aquifers, and dispersal of wastes in the ground water, however, assume great importance in determining the path and ultimately the concentration of radioactive wastes in the water. Consequently, much additional information is needed to determine the quantitative effect of these factors in the field. --Auth. summ.

12. MINERAL DEPOSITS

See also: Geologic Maps 1-2934; Areal and Regional Geology 1-2944, 1-2947; Geophysics 1-3008, 1-3013, 1-3034; Geochemistry 1-3061, 1-3070, 1-3071, 1-3072; Igneous and Metamorphic Petrology 1-3112; Engineering Geology 1-3186.

1-3140. Ford, Ronald E. GEOLOGY OF GASPÉ COPPER MINE: Can. Mining & Metall. Bull., v. 52, no. 567, p. 425-430, illus., 2 maps, 3 secs., table, July 1959, 6 refs.

One of 6 papers on the Gaspé Copper mine, Murdochville, Quebec, presented at the Annual General Meeting, Canadian Institute of Mining and Metallurgy, Montreal, Apr. 1959. Other papers deal with trackless mining, concentrator operations, smelter operations, plant engineering services, and the town of Murdochville.

All phases of the geology are presented, with particular emphasis on recent theories and ideas accumulated from underground workings. Gaspé Copper's main ore bodies are found as replacement deposits in altered limestone and as a stockwork of fracture fillings. The derivation of these deposits is attributed to the intrusion into Lower Devonian sedimentary rocks of a subjacent magma. The mine lies at the eastern end of the Shickshock mountain range, which is part of the eastern end of the continental Appalachians. The country rocks are predominantly sedimentary, being part of the Lower to Middle Devonian rocks lying in the synclinorium forming the axis of the Gaspé Peninsula. The general structure is that of closed folding. Regional jointing is very prominent. Four major fault systems have been recognized in the underground workings. The ore bodies lie within an altered aureole which has a surface area of 2 sq. mi. It is a large, low-grade zone of mineralization. --M. Russell.

1-3141. Soister, Paul E., and Dora R. Conklin. BIBLIOGRAPHY OF U.S. GEOLOGICAL SURVEY REPORTS ON URANIUM AND THORIUM, 1942 THROUGH MAY 1958: U.S. Geol. Survey, Bull. 1107-A, p. 1-167, 1959.

Most of the 2422 items listed in this bibliography were prepared originally as unpublished reports by the U.S. Geological Survey for the Division of Raw Materials and the Division of Research of the U.S.

Atomic Energy Commission and subsequently released to the public during the period 1942-May 1958. The bibliography includes U.S. Geological Survey publications and open-file reports, U.S. Atomic Energy Commission releases of Survey reports, and articles by Survey authors in scientific journals and books. It does not include abstracts published in abstract journals. Most of the references concern the geology, mineralogy, or chemistry of U or Th; some are on Be, Li, and other rare elements of interest in the atomic energy program. --From auth. introd.

1-3142. Fortson, Charles W., and Alfred T. Navarre. MONAZITE-BEARING PEGMATITES IN THE SOUTH GEORGIA PIEDMONT: Econ. Geology, v. 54, no. 7, p. 1309-1311, map, Nov. 1959, 6 refs.

Two monazite-bearing pegmatites near Culloden, Georgia, are described briefly. Both occupy NE.-trending shears (thought to be part of the Goat Rock fault zone) in a complex series of schist and gneiss, apparently of volcanic origin, similar to the Carolina Slate belt and the Little River series.

One quartz-potash feldspar pegmatite is an elongate, semiconcordant body trending N. 40°E., containing occasional monazite crystals less than 1/4 in. across. In a second pegmatite, larger monazite crystals locally cut the foliation.

The origin of the pegmatites is uncertain. They were probably injected after development of the shear zones during or after Permian time, and may be derived from nearby granites. Extensive radiometric highs in this part of the state indicate that other pegmatites probably exist. --J. A. Chamberlain.

1-3143. Kern, B.F. GEOLOGY OF THE URANIUM DEPOSITS NEAR STANLEY, CUSTER COUNTY, IDAHO: Idaho Bur. Mines & Geology, Pamph. 117, 40 p., 8 pls. incl. geol. map, July 1959, 29 refs.

The Stanley U area is in T. 11 N., R. 13 and 14 E., Boise Principal Meridian, approximately midway between the Idaho towns of Challis and Ketchum on U. S. Highway 93. The topography is rugged; the mean elevation is about 7,300 ft.

The Cretaceous Idaho batholith, dominantly quartz monzonite, forms the basement and is nonconformably overlain by the Oligocene-Miocene Challis formation. The Challis formation in the Stanley area consists of 2,000 ft. of tuffs and flows of intermediate composition, with a 100-ft. sequence of clastic terrestrial sedimentary rocks at the base. Silicic hypabyssal rocks, probably early Tertiary, intrude the batholith. Isolated patches of till are present on ridge tops. Fractures are the dominant structural feature, and the major fracture sets strike N. 45°W., N. 60°-70° E., and N.

U occurs: 1) in steeply dipping fractures in batholithic rocks and silicic intrusive rocks, and 2) disseminated in beds of arkosic conglomerate at the base of the Challis formation. Uraninite is the ore mineral in at least one of the bedded deposits. Both supergene ores and hypogene ores are present in the Stanley area. Few of the deposits have been explored to depths greater than 20 ft.

The known deposits are distributed in a northwesterly trending belt across the Stanley area. Fractures are the primary control in all deposits, and the N. 45°W. set of fractures is the most important. The following characteristics of the Stanley U deposits indicate their hydrothermal origin: 1) the control of the deposits by fractures, 2) the presence of such minerals as uraninite, marcasite, and stibnite in the ore, as well as the presence of a chalcedony gangue in some vein deposits, and 3) the hydrothermal alteration of the host rocks. The deposits are probably contemporaneous with the Challis volcanic rocks.

Sixteen groups of claims have been staked, totaling over 230 claims. Each group is described in the text. Approximately 2,300 tons of ore averaging near 0.25% U_3O_8 have been produced from the Stanley U deposits. Careful grade control will have to be maintained during mining. If sufficient reserves are developed, the feasibility of up-grading the ore should be determined. Fracture and host-rock control should be used as ore guides. Exploration has a reasonable expectancy of finding more ore, but there is no evidence which indicates that large ore bodies should be expected. --Auth

1-3144. Davidson, C.F. FURTHER OBSERVATIONS ON URANIFEROUS CONGLOMERATES: Econ. Geology, v. 54, no. 7, p. 1316-1320, Nov. 1959, 13 refs.

In the Witwatersrand-type formations, the highest U content is almost always associated with coarsest grained sediments. The diameter of the U particles averages 75 microns, while the average of the quartz grains is 1.4 mm., and it is calculated that the rate of settling in water of the quartz grains is 70 times speedier than that of the U particles. This argues strongly against a detrital origin for the U.

U is consistently in excess of Th in the Witwatersrand [South Africa] ores by a factor of about 25:1. This contrasts with alluvial ores where Th is invariably in excess of U, and again argues against a syngenetic origin for U.

The higher Th content of the Blind River [Ontario] conglomerates does not mean that the U is syngenetic. However, Th-rich minerals such as monazite and zircon are probably of detrital origin. --J. A. Chamberlain.

1-3145. Junner, N.R. THE OCCURRENCE OF URANIUM IN ANCIENT CONGLOMERATES: Econ. Geology, v. 54, no. 7, p. 1320-1323, Nov. 1959, 5 refs.

Previous inferences that pyrite is a rare alluvial mineral in Ghana are not justified because of biased samples studied. Pyrite is actually a common constituent of gravels and sands.

The depth of decomposition of bedrock is seldom 200 ft. Outcrops are common, and bedrock is generally within 10 ft. of the surface.

The Tarkwa Au bankets unconformably overlie Birrumian rocks and are of 2 types: 1) free milling quartz reefs, and 2) refractory sulfide replacements. They consist of a nonauriferous basal conglomerate (Kawere) overlain by the Banket series, the Tarkwa phyllites, and the Huni sandstone.

Six lines of evidence are presented that point to a detrital origin for the Au. In addition, the Fe:Ti ratio in the bankets (15:1) is little different from other Tarkwaian and Birrumian rocks.

Very little is known about the occurrence of U in Ghana. --J. A. Chamberlain.

1-3146. Machamer, Jerome F. THE APPLICATION OF Eh-pH DATA TO METASOMATIC DEPOSITS: Econ. Geology, v. 54, no. 6, p. 1122-1125, diag., Sept.-Oct. 1959, 4 refs.

The best explanation for the observed mineral assemblage and paragenetic sequence of some metasomatic Fe deposits about 6 mi. NW. of Ottawa, Ontario, was provided by the application of data on the Eh-pH stability relations for the couples S^{--}/SO_4^{--} and Fe^{++}/Fe^{+++}. A diagram showing the change in oxidation potential with pH for these couples is given along with an explanation of its application to the deposits studied. --M. Russell.

1-3147. Bekturov, A.B., A.I. Mun, and R.S. Darer. MAGNESIUM CHLORIDE IN THE SALT LAKES OF NORTHERN KAZAKHSTAN. Prepared by U.S. Joint Publications Research Service: Internat. Geology Rev., v. 1, no. 9, p. 28-32, 3 maps, diag., 3 tables, Sept. 1959, 6 refs.

Salt lakes of northern Kazakhstan [U. S. S. R.] including lakes Zhalauly, Kyzylkak, and Teke, are potential sources of Mg salts and other metallic salts required by industry. These salts, after preliminary evaporation in summer (intermittent) basins, are further concentrated and become raw materials from which metals are extracted, particularly for electrolytic Mg. Reserves are in lake Zhalauly: 10 million tons $MgCl_2$ and 25 million tons NaCl; lake Kyzylkak: 4.4 millions tons $MgCl_2$, 1.3 million tons $MgSO_4$, and 23.5 million tons NaCl; and lake Teke: 20 to 25 million tons $MgCl_2$. --G. E. Denegar.

1-3148. Cadilla, José F. LIMESTONE AND MARBLE RESOURCES OF PUERTO RICO: Puerto Rico, Div. Mineralogy & Geology, Bull. 3, 62 p., tables, 1959, 61 refs.

About two thirds of Puerto Rico is underlain by the older complex of highly distorted, somewhat metamorphosed Cretaceous and early Tertiary rocks. These make up the mountainous core of the island and are a heterogeneous complex of granitoid rocks, basic to intermediate flows and intrusives, and sediments. In the sediments, calcareous rocks are common, and beds of limestone and marble, with a maximum thickness of at least 100 m., are found in the section.

The Cretaceous limestones and marbles are generally detrital and relatively pure. They are folded and in places dip at high angles and tend to form linear ridges which stand above the surrounding lithologic elements.

The older complex tends to contain more calcareous rocks toward the south, and nearly all of the marble deposits are found in the southern part of the island. Among the most promising are the thick, persistent marble unit that is just N. of Juana Díaz, the Rosario deposits, and a bed of black marble between Cidra and Aguas Buenas.

The remaining third of the island is underlain by relatively undisturbed Tertiary rocks made up, in large part, of limestone and marl, with appreciable quantities of clay, conglomerate, and sandstone, especially toward the base. The Tertiary rocks, which range from Oligocene to Pliocene(?) in age, lie unconformably upon the older complex and crop out in 2 broad belts along the N. and S. coasts. They were deposited contemporaneously in these now widely separated basins, although possibly connected across the island at the time of deposition. The N. coast basin is the larger of the 2 in area, although the S. coast basin has a thicker known section.

The northern Tertiary basin extends from Loíza on the E. to Rincón on the W. The oldest units are the San Sebastián formation, the Lares limestone, and the Cibao marl with its interfingering Guajataca member, all of which make up the Río Guatemala group. Above the Río Guatemala group are the Aguada limestone and, forming the uppermost Tertiary sediments, the Aymamón limestone.

The southern Tertiary basin extends from Isla de Vieques on the E. to Isla de Mona on the W., with the main area extending from Salinas on the E. to Cabo Rojo on the W. The Juana Díaz formation is at the base, and above it, the Ponce limestone.

Quaternary coastal sands and reef debris are present all along the coasts, and in one area, Cayo Icacos, form the purest limestone being commercially produced in Puerto Rico.

One occurrence of dolomite, a Quaternary caliche(?) in the southwestern part of the island, and an occurrence of dolomitic limestone in the northwestern part of the island are known, and, although no systematic series of analyses have been made for the entire island, the low Mg content indicated by analyses of limestones from most of Puerto Rico indicates that dolomite is not common.

Industrial quarries in most of the limestone units of the island furnish large amounts of aggregate for construction and roads. Younger Tertiary limestone is used as the major raw material for the cement mills at Guaynabo and Ponce, and calcareous beach sands are a major source of construction sands. A large part of the needs for lime in Puerto Rico are furnished by locally burned limestone.

At present, all the cut marble used in Puerto Rico for construction and monuments is imported from Italy and the United States. --Auth.

A list of quarries, corporations, and owners is given (p. 20-29); also chemical analyses of Puerto Rican limestones.

1-3149. Odintsov, M.M. BASIC FEATURES OF THE GEOLOGY OF THE SIBERIAN DIAMOND PROVINCE. Prepared by U.S. Joint Publications Research Service: Internat. Geology Rev., v. 1, no. 9, p. 42-46, Sept. 1959, 14 refs.

The discovery of ultrabasic rocks and of diamonds in Upper Triassic-Lower Jurassic kimberlite pipes in the Siberian platform gave impetus to the search for diamond deposits in this area. The discovery of diamond placers in Mesozoic and Cenozoic marine and nonmarine sediments in 1948 intensified the search. The geology of the area is characterized, as is that of the African diamond fields by considerable faulting and heterogeneous composition of the basement, the development of large depressions, and a magmatic cycle dominated by basic and ultrabasic magmas. Many unexplored areas within the platform, undoubtedly having similar characteristics, are potential diamond producers. --G. E. Denegar.

1-3150. Dingle, W.B. DEVELOPING CANADA'S NORTH - HALF THE AREA OF CANADA: Can. Mining & Metall. Bull., v. 52, no. 562, p. 112-115, 2 maps, Feb. 1959.

Exploration to date indicates a tremendous potentail in oil and mineral wealth. Producing mines in the Canadian North include the U mines at Beaverlodge, Marion River, and Great Bear Lake; Au mines at Yellowknife, Great Slave Lake; Pb-Ag mines in the Mayo district, Yukon; placer workings in the Klondike; and the rich asbestos mine at Cassiar, B. C. Many other ore bodies have been found; the Pb-Zn deposits at Pine Point, S. shore of Great Slave Lake, are estimated as the largest known deposits of their kind in Canada, and possibly in the world. In the Coppermine region on the arctic coast, Cu, Pb, and

Ni exploration has begun, and large deposits are indicated. Use of aerial photographs, helicopters, airborne magnetometers, and other scientific devices make it possible to map and explore large areas quickly and efficiently. Possible overlapping of mineral and petroleum developments is indicated around McMurray and Great Slave Lake, northern Yukon and Mackenzie Valley, and the Canadian Arctic Islands.

Factors delaying development have been climate and remoteness. Development of railways, air transport, highways and roads is briefly described; also continued aerial mapping of the region, including the proposed 6-year aerial survey in the Arctic Islands. Known and potential reserves of petroleum and natural gas in the N. will become of great importance in supplying fuel required by mining and other industries elsewhere. Arctic frontiers have become of vital importance for national and continental defense. These aspects alone should encourage an expanded development of the region. --A. C. Sangree.

1-3151. Stonehouse, D.H. THE MINERAL INDUSTRY OF NOVA SCOTIA - 1958: Can. Mining & Metall. Bull., v. 52, no. 569, p. 585-586, Sept. 1959.

The value of Nova Scotia's mining industries for 1958 is estimated at $64, 000, 000. Coal production came from 28 mines and exceeded 5 million tons. More than 90% of Canada's production of barites came from the mine at Walton. Total value of clay products is estimated at nearly 1.5 million dollars. Two areas produce commercial granite. Gypsum production fell to 3, 154, 248 tons. Limestone was produced from Indian Point near East River and limestone and dolomite were produced at Upper Musquodoboit. Research continues on oil shale development. Exploration for oil continued, but no production is reported. Two companies produced 126, 374 tons of salt. Crushed stone has become a major industry. --M. Russell.

1-3152. Illinois, Division of Industrial Planning and Development. MINERAL RESOURCES: Its: Atlas Illinois Resources, Sec. 2, 59 p., 23 maps (1 fold.), 2 secs., 18 graphs, June 1959, approx. 75 refs.

The Atlas of Illinois Resources is being published in a series of 10 separate documents. Section 1, Water Resources and Climate, was published in Nov. 1958. Forthcoming sections will describe Illinois farms and forests, people and educational facilities, transportation and public utilities, markets and manufacturing, and recreational and governmental characteristics.

The state's mineral industry provides materials for a wide range of economic activities. The primary materials of industrial production, fuels and iron ore, the latter from the Lake Superior district, are available in abundant quantities. In addition, certain minerals essential in the initial processing of steel, such as refractory materials and fluxes, are present in the area; also mineral substances necessary for foundry, chemical, construction, and other purposes. Coal and oil are the leading minerals in value.

This report covers the following topics: mineral resources of Illinois; physiography; geology; coal industry; coal beds; coal resources; oil and gas; oil production; natural gas; limestone and limestone products; sand and gravel; clay and clay products; fluorspar, special sands, metals, and tripoli; undeveloped minerals of potential importance; brines for industrial use; iron and steel; topographic maps with list of those available; land divisions; mining laws; agencies supplying information relating to mineral resources in Illinois; selected reference list of documents pertaining to mineral resources; glossary; index of counties, cities, and towns. --L. M. Dane.

1-3153. Luedke, Elaine M., Chester T. Wrucke, and John A. Graham. MINERAL OCCURRENCES OF NEW YORK STATE WITH SELECTED REFERENCES TO EACH LOCALITY: U.S. Geol. Survey, Bull.1072-F, p. 385-444, fold. map (in pocket) scale 1:500, 000, 1959, refs.

References and locations were compiled for more than 1,000 mineral occurrences in New York State. Each occurrence is shown on an accompanying map and is given by commodity and county in a locality list. Fuels, sand and gravel, and clay are not included in this report. --Auth.

13. FUELS

See also: Structural Geology 1-2963; Stratigraphy 1-2974; Geochemistry 1-3063.

1-3154. Owen, Edgar W. THE ACREAGE FACTOR IN OIL EXPLORATION: Natl. Oil Scouts & Landmen's Assoc., v. 4, no. 8, (1959 Annual), p. 17-18, port., Aug. 1959.

The entire oil country in the United States is now so tightly leased that acreage availability has become the limiting factor for any new exploratory effort. The experienced prospector in a familiar oil province can assign mathematical odds to the probability of any new well bringing in production. In order to drill in an area where the risk is 10 to 1 the operator must control leases in at least 10 locations, if the risk is 50 to 1, he must control leases in 50 locations, and in each case the profit potentiality must be equal to the ratio of the odds against a successful well. The only major source of economic improvement in the present squeeze in the more efficient employment of diverse holding in orderly exploration and development programs. --M. Russell.

1-3155. Landes, Kenneth K. PETROLEUM GEOLOGY: 2d ed., 443 p., 108 figs. incl. port., illus., maps, secs., diags., graphs, logs, 2 tables, New York, John Wiley & Sons, 1959, 57 refs.

During the 8 years since the first edition was published, geology and other facets of oil finding developed to such an extent that 70 to 75% of the book was rewritten. The new book can be divided into 3 parts. The first 2 chapters acquaint the reader with the background of professional petroleum geology and with oil and gas drilling and production methods. The latter methods also provide background material, with emphasis on the ways in which petroleum technology impinges upon the activities of the geologist.

Chaps. 3 and 4 are concerned with the techniques of the petroleum geologist. Practice, however, is presented before theory in this book so that the beginner will learn the language of the specialist and observe the sources of evidence and methods of study used in developing the theoretical concepts. The technical aspects of oil finding are not presented in professional detail.

The remainder of Petroleum Geology is concerned with the geologic occurrence of petroleum. The more knowledge of the origin, migration, and accumulation of oil, the more intelligent will be the prospecting and the more widespread the results. This "academic" side of petroleum geology is actually intensely practical. The emphasis, wherever occurrence of oil is discussed in this book, is on the manner in which the hydrocarbons have been trapped rather than on details of stratigraphic nomenclature.

An appendix, "The Literature of Petroleum Geology," is included in order to give the student a concise list of modern references.

A considerable part of the first edition, which concerned the distribution of oil and gas fields throughout the world and future oil supplies, has been eliminated. This material will be expanded and published in a separate volume, Petroleum Geology of World Oil Fields, which is now in preparation. --From auth. pref.

Contents: The profession of petroleum geology; drilling, completing, and producing oil and gas wells; exploration; subsurface and production geology; origin and evolution of oil and gas; reservoir rocks; reservoir fluids; reservoir seals; migration of oil and gas; traps: introduction and dry syncline type, anticlinal, salt-cored, hydrodynamic and fault, varying permeability; regional aspects of accumulation.

1-3156. Berry, James E. ACOUSTIC VELOCITY IN POROUS MEDIA: Jour. Petroleum Technology, v. 11, no. 10, p. 262-270, 16 graphs, 5 logs, Oct. 1959, 10 refs.

An evaluation is made of the acoustic velocity log for measurement of formation porosity. Plots of field-observed velocities vs. core-measured porosities of sandstones and limestones with intergranular porosity show that the velocity log gives a useful measure of porosity, in agreement with published data. A new method of plotting electrical and velocity log data makes it easier to recognize hydrocarbon-water contacts from log data and to make semi-quantitative estimates of hydrocarbon saturation. Two examples of this interpretation technique are given. This paper also discusses the various factors that affect acoustic velocity and shows how corrections can be made for some of these factors. --Auth.

1-3157. Jacobsen, Lynn. SEDIMENTATION OF SOME SPRINGER SANDSTONE (MISSISSIPPIAN-PENNSYLVANIAN) RESERVOIRS, SOUTHERN OKLAHOMA: Am. Assoc. Petroleum Geologists, Bull., v. 43, no. 11, p. 2575-2591, 5 illus., map, 3 secs., 2 graphs, table, Nov. 1959, 24 refs.

The major oil reserves found in Springer sandstones have been found in the giant Velma and Sholom Alechem fields and in the adjacent smaller fields of Carter and Stephens counties, Oklahoma. These oil fields occur on prominent high-relief closed structural features, but a considerable part of the control on the oil accumulation is depositional.

Thick and prolific reservoir sandstones occur at structurally high positions on these uplifts, but characteristically these sandstones become thin-bedded and shaly downdip.

Deposition of the reservoir sandstones in an environment of high energy and normal open marine oxidation and pH level is indicated by good sorting, massive bedding, and the presence of glauconite and a benthonic fauna. In contrast, the adjacent nonreservoir Springer sediments seem to have been deposited in a somewhat stagnant environment. This is indicated by the unwinnowed sands, abundant siderite, absence of a benthonic fauna, and the bituminous shales.

Evidence is presented that the structural elements were being developed during sedimentation, and that they had appreciable topographic relief. On the topographic highs an environment was favorable to the deposition of excellent oil reservoirs, and in the lower protected areas the environment resulted in the deposition of a favorable source facies.

The conclusion is reached that the chief importance of structure in controlling the oil accumulations is indirect - that is, in the influence of the developing structure on sedimentation. The local sedimentational pattern is considered to be the critical factor in the development of the oil fields. --Auth.

1-3158. Miller, Don J., Thomas G. Payne, and George Gryc. GEOLOGY OF POSSIBLE PETROLEUM PROVINCES IN ALASKA. With an Annotated Bibliography by Edward H. Cobb: U.S. Geol. Survey, Bull. 1094, 131 p., 7 maps, (4 under separate cover), 2 secs. (under separate cover), 6 tables, 1959, 113 refs.

Alaska is divided into the southern, central, and northern major geologic-physiographic regions for the purpose of appraising its petroleum possibilities.

Southern Alaska, an area of 185,000 sq. mi., includes the arcuate mountain chain formed by the Alaska and Aleutian ranges and the Mentasta-Nutzotin Mountains, the coastal range and valley area to the S., and the southeastern Alaska "panhandle." On the basis of geology, surficial indications of petroleum, and test wells drilled, 6 possible petroleum provinces are indicated in southern Alaska.

Central Alaska, a region of about 275,000 sq. mi., consists of an irregular assemblage of intricately dissected uplands and alluvium-floored lowland basins. Scattered peaks of resistant intrusive igneous rocks surmount most of the upland areas. Based on the limited amount of available information, central Alaska cannot be regarded as distinctly favorable for significant accumulations of petroleum. However, 3 Cenozoic provinces, the Yukon-Koyukuk, the Kobuk, and the Kandik, and several large Cenozoic basin provinces may be worthy of further investigation.

Northern Alaska, an area of about 125,000 sq. mi. includes the Brooks Range and all the treeless tundra N. to the Arctic Coast. Oil and gas deposits have been discovered, and geologic conditions are favorable for other oil and gas accumulations in approximately half of the region. Total recoverable reserve estimates for all discoveries in northern Alaska range from 30 to 100 million barrels of crude oil, and from 370 billion to 900 billion cu. ft. of gas. --G. Gryc.

1-3159. Baptist, Oren C. OIL PRODUCTION FROM FROZEN RESERVOIR ROCKS, UMIAT, ALASKA: Jour. Petroleum Technology, v. 11, no. 11, p. 85-88, 2 graphs, 3 tables, Nov. 1959, 7 refs.

The Umiat oil field is in U. S. Naval Petroleum Reserve No. 4 between the Brooks Range and Arctic Ocean in far northern Alaska. The Umiat anticline has been tested by 11 wells, 6 of which produced oil; however, the productive capacity and recoverable reserves of the field are subject to considerable speculation because of unusual reservoir conditions and because several wells appear to have been seriously damaged during drilling and completion.

Oil is produced at depths of 275 to 1,100 ft.; the depth to the bottom of the permanently frozen zone varies from about 800 to 1,100 ft., so that most of the oil reserves are in the permafrost. Reservoir pressures are estimated to range from 50 to 350 p.s.i., increasing with depth, and the small amount of gas dissolved in the oil is the major source of energy for production.

Laboratory tests were made on cores under simulated permafrost conditions to estimate oil recoverable by solution-gas expansion from low saturation pressures. The cores were also tested for clay content and susceptibility to productivity impairment by swelling clays and increased water content if exposed to fresh water.

The results indicate that oil can be produced from reservoir rocks in the permafrost and that substantial amounts of oil can be produced from depletion-drive reservoirs by a pressure drop of as little as 100 p.s.i. below the saturation pressure. Freezing of formation water reduces oil productivity much more than that due to increased oil viscosity. Failure of wells drilled with water-base mud to produce is attributed to freezing of water in the area immediately surrounding the wellbore. Swelling clays apparently contributed very little to the plugging of the wells. --Auth.

1-3160. Kansas Geological Society. KANSAS OIL AND GAS FIELDS, VOLUME II. WESTERN KANSAS: 207 p., maps, cross secs., logs, tables, [Wichita?], Kansas, Oct. 1959.

The first volume of oil and gas fields, published in 1956, covered fields in S.-central Kansas. The second volume in this series is a compilation of 33 papers on fields W. of Range 25 W., the author's name appearing on each paper. The Research Committee of the Kansas Geological Society selected the fields included in this book. Selection was based on geological significance, economic importance, and geographical location. The Society plans to issue revised and supplementary field papers which will eventually give complete field coverage in later editions of this volume. To date, a total of 59 fields has been covered by the 2 volumes.

Fields are listed alphabetically by name. For each field the following information is given: location; method of exploration leading to discovery; discovery; nature of trap; productive area and type drive; thickness and lithology of reservoir rocks; thickness of productive zone; character of oil; water production; completion treatment; marketing facilities; production history; required surface casing; average well costs. --A. C. Sangree.

1-3161. Zaffarano, R.F., C.Q. Cupps, and J. Fry. PROPERTIES AND BEHAVIOR OF RESERVOIR OIL IN THE ANETH FIELD, UTAH: Jour. Petroleum Technology, v. 11, no. 11, p. 33-36, 3 ports., 2 maps, 5 graphs, 3 tables, Nov. 1959, 8 refs.

Data are presented which show the PVT characteristics of the reservoir oil in the Aneth field, San Juan County, Utah. The data were obtained principally from the analysis of subsurface oil samples taken from 7 wells within 2 years after discovery of the field. The uniformity of the oil across the large producing area is discussed, and information on the development history and geology of the area is also given. The Aneth field is the first of several fields to be studied to provide data for a general investigation of the relative characteristics of Pennsylvanian reservoir oils in the Paradox basin. --Auth.

1-3162. Olenin, V.B., B.A. Sokolov, and A.A. Trokhova. PROSPECTS OF OIL-GAS DEPOSITS IN CRETACEOUS SEDIMENTS IN THE COLCHIS LOWLAND AND ADJACENT FIELDS. Translated by Salih Faizi: Internat. Geology Rev., v. 1, no. 9, p. 19-23, map, sec., Sept. 1959, 6 refs.

The Riono-Chernomorsk structural basin, which extends under the Black Sea and part of western Georgia, is becoming increasingly important in oil and gas exploration. Tectonically, its western Georgia portion is divided into 3 regions: Guri, Abkhazk-Megrel, and the Colchis lowland. A structure-contour map drawn on the surface of Upper Cretaceous sediments in the Colchis area revealed, generally, brachyanticlinal structures. These sediments, largely composed of carbonates as thick as 2,000 m., occur throughout the Colchis area within drilling depth (1,000 to 3,000 m.). It is postulated that bitumen formation could have occurred in the sediments; however, processes of oil migration into the area are discussed. The character of Tertiary sediments in relation to regional-structural-stratigraphic control indicates that they are possible oil and gas reservoirs. --D. D. Fisher.

1-3163. Luginets, I.P. THE PROBLEM OF OIL-GAS SATURATION IN THE MESOZOIC SEDIMENTS OF THE LOWER YENISEI. Translated by Salih Faizi: Internat. Geology Rev., v. 1, no. 9, p. 24-27, Sept. 1959, 2 refs.

Exploratory drilling in Mesozoic argillites, sandstones, and shales of the still-subsiding Yenisei basin [U. S. S. R.] located numerous gas and oil occurrences. Contained organic-oil content of Lower Jurassic sediments is 1.5%; of Middle Jurassic, 1.8% (locally 3.7% in Bajocian sediments); of Upper Jurassic, 1.4%; and of Valanginian, 1%. Maximum gas flow from Bajocian and Valanginian sandstone was 13,000 m.^{3} per 24 hours; gas flowed at a rate of 76,000 m.^{3} in 24 hours at depth of 612 to 627 m. from Middle Jurassic sandstone. These and other factors, including evidence that the sediments were largely accumulated in shallow-water and reducing conditions, indicate that the Jurassic and Valanginian sediments of the Ust-Yenisei basin are potential oil producers. --G. E. Denegar.

1-3164. Tainsh, H.R., K.V. Stringer, and J. Azad. MAJOR GAS FIELDS OF WEST PAKISTAN: Am. Assoc. Petroleum Geologists, Bull., v. 43, no. 11, p. 2675-2700, 9 maps, chart, 2 secs., diag., table, Nov. 1959, 11 refs.

The Sui gas field in NE. Baluchistan was discovered by a test well completed by Pakistan Petroleum Limited in 1952. After the drilling of 5 more wells on the large exposed dome, the reserves of recoverable natural gas were estimated to be 4-5 million million cu. ft. The gas occurs in porous Eocene limestone and contains approximately 90% methane, 4.5% carbon dioxide, 3.5% N, with some hydrogen sulfide. In 1954-1955 a 16-in. pipeline was constructed from Sui to Karachi with a purification plant at Sui; sales of purified gas began in Sept. 1955, and at the end of 1958 were 35 million cu. ft. per day.

The proof of large gas reserves encouraged further drilling in the region, and subsequently 5 more big domes have been tested - Zin on the NW., Uch and Jacobabad on the W., Khairpur on the S., all by Pakistan Petroleum Limited, and Mari on the SE. by the Pak-Stanvac Petroleum Project.

Each of the tested structures has proved gas accumulations in Eocene limestones, but not all in the same formation. The pools are nearly all large, but the composition of the raw gas has shown remarkable differences. The methane content varies from 90% at Sui to 12% at Khaipur, and the carbon dioxide content from 6% or less at Mari and Sui to 70% at Khairpur.

The total volume of recoverable methane in the region is estimated to be over 10 million million cu. ft., but none of the wells drilled so far has given evidence of liquid hydrocarbons in appreciable quantities. The gas overlies saline water. Minor shows of oil have been observed, and flowing gas is accompanied by a little "condensate"; bitumen is widely distributed in the Eocene rocks.

Because of the widespread distribution of shows of hydrocarbon and other gases it is not possible to reach definite conclusions regarding the source rocks and migration paths, but it is suggested that the Eocene and Cretaceous shales have been the source of much methane, and the carbon dioxide and some N may have come from Cretaceous and Jurassic limestones. Much of the N perhaps with carbon dioxide may be the result of deep-seated igneous intrusions.

The migration of the gases is studied against the background of the complex geological history of the region. --Auth.

1-3165. Rose, Harold J. RESEARCH POTENTIALS FOR THE COAL INDUSTRY: Can. Mining & Metall. Bull., v. 52, no. 569, p. 559-563, Sept. 1959, 12 refs.

A report is made on developments which suggest the trends to be followed in the next few years in the coal industry. Geophysics is playing an increasing role in exploration. A hydraulic drilling method has been devised to sink mine shafts. Continuous mining machines have been developed which will mine 5 tons of coal a minute in fairly thick seams and 3 tons a minute in seams 30 to 48 in. thick. Ground support and control is of increasing importance in strip mining as the pits become deeper. Hydraulic mining methods with vertical lifts up to 650 ft. have been devised in the U. S. S. R. Developments in strip mining, use of explosives, underground gasification, coal preparation, and use of radioisotopes are described. --M. Russell.

1-3166. Lyuber, A.A. CHIEF TRENDS IN RESEARCH ON COAL PETROGRAPHY IN THE U.S.S.R. AND ABROAD. Translated by Royer and Roger, Inc.: Internat. Geology Rev., v. 1, no. 9, p. 12-18, 2 tables, Sept. 1959, 27 refs.

Soviet scientists have achieved considerable success in the application of petrography to the study of coal, despite lack of coordination among various specialists studying coal genesis, metamorphism, and structure, and the inadequate application of modern methods of investigation. An appraisal of coal petrography in the Soviet Union and in other nations shows that the scope of problems which interest coal petrographers is universal, but the presentation of problems, development of details, and purpose of study are very different. --G. E. Denegar.

1-3167. Barnes, Farrell F., and Edward H. Cobb. GEOLOGY AND COAL RESOURCES OF THE HOMER DISTRICT, KENAI COAL FIELD, ALASKA: U.S. Geol. Survey, Bull. 1058-F, p. 217-260, 4 maps (3 under separate cover, 2 geol. maps scale 1: 63,360), 9 secs. (under separate cover), 2 tables, 1959, 13 refs.

The Homer district of the Kenai coal field is about 100 mi. SW. of Anchorage, in S.-central Alaska. It covers an area of about 1,100 sq. mi. on the W. side of the Kenai Peninsula, between Tustumena Lake and Kachemak Bay. The principal settlement is Homer, at the southern end of the district, which is connected by the gravel-surfaced Sterling Highway with the Alaska highway system and the Alaska Railroad, and is also served by ocean transportation and one airline.

About 5,000 ft. of nonmarine sedimentary rocks of early Tertiary age is exposed in the district, which is the type area of the coal-bearing Kenai formation. The total thickness of the formation, as well as its relation to older rocks, is unknown, as neither the top nor the base has been found. The bedrock is mostly concealed, except in beach bluffs and along the larger streams, by glacial and alluvial deposits of Quaternary age.

The structure of the district is relatively simple, being characterized by a broad structural basin or trough locally modified by gentle folds and by high-angle faults with displacements ranging from a few inches to nearly 80 ft.

The coal of the Homer district ranges in rank from lignite to subbituminous B, but the greater part is subbituminous C. Coal beds are present throughout the known thickness of the Kenai formation but are thickest and most abundant in the lower part at the S. end of the district, where at least 30 beds ranging from 3 to 7 ft. in thickness, as well as many thinner beds, were measured. Although mining has been attempted from time to time since 1888, very little coal has been produced commercially to date.

Indicated reserves, largely within half a mile of the shores of Cook Inlet and Kachemak Bay and in beds containing 2 ft. or more of coal, were estimated at about 400 million tons. Much larger reserves are undoubtedly present farther inland, but surface data are insufficient for reliable estimates. --Auth.

14. ENGINEERING GEOLOGY

See also: Geophysics 1-3032; 1-3052.

1-3168. Pickett, A.G., and M.M. Lemcoe. AN INVESTIGATION OF SHEAR STRENGTH OF THE CLAY-WATER SYSTEM BY RADIO-FREQUENCY SPECTROSCOPY: Jour. Geophys. Research, v. 64, no. 10, p. 1579-1586, 4 diags., 3 graphs, Oct. 1959, 15 refs.

This paper summarizes a soil mechanics study of the clay-water system made with steady-state nuclear magnetic resonance as the analytical tool. Although the study was limited to measurements of the contribution of water-lattice strength to the shear strength of clay soils, the results demonstrate the utility of the techniques of radio-frequency spectroscopy in such investigations. The authors conclude that water-lattice strength is of negligible significance in determining the shear strength of wet clay soils. --Auth.

1-3169. THIRD SYMPOSIUM ON ROCK MECHANICS. Papers and Discussions from the Third Symposium on Rock Mechanics Held at the Colorado School of Mines, Golden, April 20-22, 1959: Colorado School Mines, Quart., v. 54, no. 3, p. 1-366, illus., maps, secs., diags., graphs, tables, July 1959, refs.

The symposium was the first held under the joint auspices of the mining engineering departments of Minnesota University, Pennsylvania State University, and the Colorado School of Mines. The general theme of the 4 sessions was the broadness of the field of rock mechanics and the fact that it is of interest to men representing mining engineering, civil engineering, geology, military engineering, and physics, among others. The sessions entered into the fields of crushing or comminution, of soil mechanics, geophysics, and nuclear blasting, all of which lie within or are related to the field of rock mechanics.

The symposium is divided into 4 parts as follows, each part consisting of individual papers followed by discussion of the part as a whole:

Pt. 1. Factors Common to Comminution, Underground Failures, and Failures Resulting from Explosions, p. 1-90. 5 papers.

Pt. 2. Factors Common to Soil Mechanics and Rock Failure, p. 91-216. 5 papers.

Pt. 3. Explosions and Seismology, p. 217-309. 5 papers.

Pt. 4. Nuclear Blasts in Mining, p. 311-364. 4 papers.

Symposium Summary, by Howard L. Hartman, p. 365-366.

Each of the papers is abstracted separately below, in the order in which it appears in the symposium. --A. C. Sangree

1-3170. Wuerker, Rudolph G. INFLUENCE OF STRESS RATE AND OTHER FACTORS ON STRENGTH AND ELASTIC PROPERTIES OF ROCKS (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 3-31, 12 figs. incl. diags., graphs, 7 tables, July 1959) 31 refs.

In the "Standardized Tests for Determining the Physical Properties of Mine Rock" proposed by the U. S. Bureau of Mines, the factors conditioning the physical properties of rock are discussed, and specifications for each particular test are given. A stress rate of 100 p.s.i./sec. for the standard compression test is prescribed. Data from tests with greater speed of loading such as impact and sonic tests indicate that strength and modulus of elasticity might increase by a factor of 2. Complete data has been published on another man-made brittle material, concrete. One sample had a compressive strength of 2,500 p.s.i., another 6,500 p.s.i. Rates of stressing ranged from 1 to 10^8 p.s.i./sec., rates of straining from 10^{-16} to 10 in./in. per sec. Ability to absorb strain energy also increased with the rate of application of load.

The significance of compression, impact, and sonic tests is limited by the fact that rocks in mineral engineering are almost never subjected to a single type of stress. The influence of other factors, such as combined stresses and confinement will be discussed by using an expansion of Mohr's theory for a range within which the straight line expression for Mohr's envelope is valid. Increase of compressive strength due to confining pressure is many times higher than the one due to increased stress rate. --Auth.

1-3171. Zeleny, Richard A., and Edgar L. Piret. STUDIES OF THE ENERGY REQUIREMENTS FOR CRUSHING (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 33-42, 3 graphs, July 1959) 8 refs.

The work input-new area-surface energy-heat produced relationships in the crushing of single and multiple particles of glass and quartz in simple devices are presented. Appreciable quantities of energy can be lost to plastic deformation of the crushing device. Future investigations can well be pointed toward a study of the transition of the work input to the final energy forms and a study of the energy loss to plastic deformation of metal crusher surfaces. --From auth. summ.

Comment by L. E. Djingheuzian, p. 41-42.

1-3172. Djingheuzian, L.E., and M.A. Twidale. AN ATTEMPT TO CORRELATE GRINDING WORK INDEX VALUES WITH UNDERGROUND DRILLING AND ELASTIC DATA (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 43-60, 6 graphs, 14 tables, July 1959) 4 refs.

This correlation is a first attempt, and, as such, is admittedly an approximation. That such a correlation should be possible is indicated: 1) by the fact that drilling data obtained from Kirkland Lake mines have been satisfactorily related to the work indices, as well as the drilling data obtained by Professor Salman of McGill University; 2) by the fact that the work indices have also been satisfactorily related to blasting data from the mines.

The work index of drilling and blasting has been shown to be an important parameter for evaluating and controlling drilling and blasting operations in mines. --Auth.

1-3173. Rinehart, John S. THE ROLE OF STRESS WAVES IN COMMINUTION (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 61-76, 11 figs., July 1959) ref.

Rocks, being so much stronger in compression than in tension, can effectively transmit potentially damaging disturbances to regions remote from the sources of the disturbances. Development of an appreciation of how small rocks break up under impact loads resolves itself primarily into the geometrical problem of tracing the peregrinations of these disturbances through the rock specimen of interest, particularly with respect to mutual interactions of incident and reflected stress waves. Completion of a number of exercises of this type suggest that comminution may to a large measure be controlled by the interferences of stress waves. --Auth.

1-3174. Bond, Fred C., and Bruce B. Whitney. THE WORK INDEX IN BLASTING (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 77-82, graph, 2 tables, July 1959) 4 refs.

The energy required to break rock by blasting can be evaluated and given in terms of the blasting work index, similar to the crushing work index. It is expressed as $Wi = W\sqrt{P}/10$ where Wi is work index, W is input energy in kilowatt hours per ton, and P is the size that 80% of the broken rock passes. In specific tests, blasting appears to be more efficient than crushing. --M. Russell.

1-3175. Wilson, Stanley D. THE APPLICATION OF SOIL MECHANICS TO THE STABILITY OF OPEN PIT MINES (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 93-113, 13 figs. incl. 4 illus., map, secs., diags., graphs, July 1959) 2 refs.

In open-pit mining it is desirable to maintain the steepest slope that can be excavated safely. Most earth slides or slope failures are the result of uplift pressures in the water back of the slope, and recent tests indicate that the same conclusions apply to fractured and fissured rock. The implication that preventive measures used in stabilizing earth slopes could be applied in open-pit mining is obvious but presently not economically feasible. --M. Russell.

1-3176. Muller, Leopold. THE EUROPEAN APPROACH TO SLOPE STABILITY PROBLEMS IN OPEN-PIT MINES (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 115-133, 16 figs. incl. 3 illus., maps, secs., diags., chart, graphs, July 1959).

Arithmetical calculations of permissible slope angles, while cumbersome, are the most practical means of assuring safety with maximum slope. Rock stability and permissible angle are determined by the type of rock, the strength of rock, stratification and foliation, mechanical fragmentation, chemical defects, positional relations between slope plane and structural elements, a time factor, water in rock joints, and vibrations. --M. Russell.

1-3177. Hardy, H.R., Jr. TIME-DEPENDENT DEFORMATION AND FAILURE OF GEOLOGIC MATERIALS (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 135-175, 4 illus., secs., chart, 6 diags., 20 graphs, 5 tables, July 1959) 50 refs.

The time-dependent behavior of geologic materials under conditions of low and high uniaxial stress is considered to be important in the study of comminution and underground failure. Under low values of applied stress it is postulated that time-dependent deformation may be described approximately by a viscoelastic model. In the case of higher values of applied stress, it is postulated that time-dependent deformation and failure may be described by the combination of a viscoelastic model and a microfracture mechanism. A comprehensive review of recent and past research in this field is given. The design and calibration of laboratory apparatus to study these properties is described, together with experimental results to date. --Auth.

1-3178. Robinson, L.H., Jr. THE EFFECT OF PORE AND CONFINING PRESSURE ON THE FAILURE PROCESS IN SEDIMENTARY ROCK (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 177-199, 3 illus., 5 diags., 10 graphs, table, July 1959) 21 refs.

Results of the investigation of the effects of pore and confining pressure on the failure characteristics of sedimentary rocks are summarized in the following conclusions:

1) Common sedimentary rocks will undergo either malleable or brittle failure, depending upon the difference which exists between confining pressure and internal pore pressure.

2) Although shales, limestone, and sandstone have inherently different strengths, it was observed a) that brittle failure always occurs when the confining and pore pressures are equal, and b) that the mode of failure changes gradually from brittle to malleable as the differential between the confining and pore pressures increases the transition pressure depending on the nature of the rock and the pressure level.

3) The yield strengths of rocks increase only slightly as the confining pressure increases if the confining and pore pressures are maintained equal. --Auth. concl.

1-3179. Coates, D.F. ENERGY RELEASED IN ROCKBURSTS (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 201-205, July 1959) 4 refs.

An analysis and prediction of rockbursts is empirically possible. The unit strain energy stored in rock before rupture can be calculated from: $V_o = 1/2E (S_1^2 + S_2^2 + S_3^2 - 2/m (S_1S_2 + S_2S_3 + S_3S_1))$, where V_o is the unit strain energy, S_1, S_2, S_3 are the horizontal, tangential, and radial stresses, and m is Poisson's Number. --M. Russell.

1-3180. Langefors, Ulf. MODEL SCALE TESTS IN ROCK BLASTING: (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 219-249, 37 illus., diags., table, July 1959) 7 refs.

Plexiglass is a good material in which to perform laboratory tests to observe the effects of blasting on rocks. Not only are the physical characteristics better suited in small-scale testing than actual rock material but, as plexiglass is transparent, complete 3-dimensional effects throughout the material can be observed. Results of tests under varying conditions are given. --M. Russell.

1-3181. Grine, Donald R., and G.R. Fowles. THE ATTENUATION OF SHOCK WAVES IN SOLID MATERIALS WITH SEISMIC APPLICATIONS (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 251-269, 4 illus., 4 diags., 3 graphs, July 1959) 17 refs.

Shock waves in solids are attenuated, in general, by several mechanisms. Those common to attenuation in fluids, include the overtaking of the shock by a rarefaction wave, geometrical divergence, and heating due to irreversible processes occurring within the shock front. Mechanisms peculiar to solids include absorption of energy in plastic deformation and fracture.

Application of existing theory for fluids to solids requires knowledge of the equation of state of the solid. The theory must then be modified to include plastic deformation and fracture. Recent experiments to determine equations of state of rocks, and other experiments to determine dynamic yield strengths and fracture energies will be described. Application to the problem of energy transfer in a shot hole will be discussed. --Auth.

1-3182. Fogelson, David E., Thomas C. Atchison, and Wilbur I. Duvall. PROPAGATION OF PEAK

STRAIN AND STRAIN ENERGY FOR EXPLOSION-GENERATED STRAIN PULSES IN ROCK (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 271-284, 2 diags., 7 graphs, 2 tables, July 1959) 4 refs.

This paper presents the results from a series of linear array strain tests arranged by the U. S. Bureau of Mines and designed to determine the strain-producing abilities of 6 explosives when detonated in a granite gneiss. Both peak strain and strain energy were found to propagate through the rock according to an exponential decay law. The amount of strain produced in the rock by the explosives was found to correlate with the calculated detonation pressure. The amount of strain energy transferred to the rock, divided by the calculated energy of the explosive, was found to correlate with the characteristic impedance of the explosive. Five to 9% of the total energy released by the explosive was transferred to the rock as strain energy. --Auth.

1-3183. Clausing, D.P. COMPARISON OF GRIFFITH'S THEORY WITH MOHR'S FAILURE CRITERIA (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 285-296, 3 diags., 3 graphs, July 1959) 6 refs.

The experimental data qualitatively strongly supports Griffith's concept of failure. Griffith's criteria can be plotted as a Mohr's envelope, and all of the mathematical relationships associated with Mohr's envelope are valid. However, Griffith's Theory and experiment refute Mohr's concept of failure.

This paper is an initial consideration of the fundamentals of rock failure. Actual rock is not homogeneous, Hookean, and isotropic, and under certain conditions does not even behave as a brittle material. The details of actual fracture processes are quite complicated. Much basic work must be done before fundamental concepts of rock fracture can be of great value in engineering practice. --Auth. concl.

1-3184. Johansson, C.H. RECENT EUROPEAN RESEARCH WORK IN EXPLOSIVES (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 297-303, July 1959).

A review of research completed or underway in Europe on explosives covers 3 congresses, 4 monographs, and investigations covering the following fields: 1) initiation by heat, impact, or shock, 2) detonation conditions, 3) permitted explosives, 4) new explosives, and 5) charging of explosives. --M. Russell.

1-3185. Jeffreys, Harold. THE STRUCTURE OF THE EARTH (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 313-318, July 1959).

Determinations from artificial satellites indicate the ellipticity of the earth to be $1/(298.1 \pm 0.1)$. Evidence from seismologic observations remains the most conclusive that the core of the earth is probably liquid Fe, although possibly a further pressure modification of olivine. A summary of the earth's general structural characteristics is given. --M. Russell.

1-3186. Johnson, Gerald W. MINERAL RESOURCE DEVELOPMENT BY THE USE OF NUCLEAR EXPLOSIVES (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 319-331, 5 figs. incl. diags., 2 graphs, table, July 1959) 21 refs.; also pub. as: California, Univ., Radiation Lab. 5458.

From the standpoint of actual energy available, nuclear blasts are cheap; a safe million-ton explosion costs about $1,000,000. The potential uses for such blasts include excavation and strip mining, rock breaking in place, power production, and isotope production. Cratering is desirable for some, completely contained explosions for others. Some promising fields in which nuclear blasting might prove economically feasible include development of oil shales, low-grade ores, and tar sands. The pertinent effects of test nuclear blasts are given. --M. Russell.

1-3187. Harrison, Melvin A., and Harry B. Keller. EXCAVATION WITH NUCLEAR EXPLOSIVES (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 333-347, 7 figs. incl. 2 maps, 2 profiles, graphs, July 1959).

The application of nuclear explosives to large-scale excavation projects is feasible. The greater the yield, the lower the unit cost for energy. An experimental project to create a harbor in the Cape Thompson area in northwestern Alaska to be 1,300 ft. by 2,600 ft. with an approach channel 560 ft. by 1,700 ft. is described. --M. Russell.

1-3188. Butkovich, T.R. MECHANICAL PROPERTIES OF ICE (In: Third Symposium on Rock Mechanics: Colorado School Mines, Quart., v. 54, no. 3, p. 349-360, thin sec., 6 graphs, July 1959) 6 refs.

Ice is a substance which shows both plastic and elastic behavior when subjected to stresses of various kinds. Effects of the plastic-elastic behavior are discussed, and values of mechanical constants such as Young's modulus and viscosity coefficients, including results of laboratory and field studies, are presented for various types of ice. The mechanism underlying the deformation of ice under various conditions is indicated. The need for standardization of testing techniques is stressed. Ultimate strength, modulus of elasticity and viscosity coefficients as functions of temperature, structure, orientation, and impurities are reviewed. --Auth.

1-3189. Diment, W.H., and others. GEOLOGICAL SURVEY INVESTIGATIONS IN THE U12b.03 AND U12b.04 TUNNELS, NEVADA TEST SITE: U.S. Geol. Survey, Trace Elements Memo. Rept. 996, 74 p., 11 figs. incl. 6 maps (4 in pocket), cross sec., 14 tables, March 1959, ref.

The papers comprising the various parts of this report contain preliminary results of the U. S. Geological Survey investigations in the U12b.03 and U12b.04 tunnels at the Nevada test site, Nye County, Nevada. The geologic studies were undertaken to define the structural, chemical, mineralogic, and some of the physical properties of the tuffaceous rocks that enclose the explosion chambers at the end of each tunnel.

The U12b.03 and .04 tunnels are part of the U12b (Rainier) tunnel complex that was driven northwestward from the steep E. slope of Rainier Mesa.

The rocks penetrated by the U12b tunnel complex are part of the Oak Spring formation (Tertiary) and are predominantly tuffs and tuffaceous sandstones. The Oak Spring formation in vicinity of the tunnel is about 1,900 ft. thick and unconformably overlies limestones, dolomites, quartzites, and siliceous shales of late Paleozoic age. The contact between the Tertiary and Paleozoic rocks strikes N. 11°W. to N. 65°E. and dips 12° to 22° NW. to SW. The contact is highly irregular, and locally relief is as much as 30 ft. The Paleozoic rocks trend N. to NE., dip 10° to 70° W. to NW., and have been cut by many NW.- to NE.-trending steeply dipping normal and reverse faults. Several folds of small amplitude and N.- to NW.-trending faults with vertical displacement of as much as 50 ft. have been mapped in the Tertiary rocks. These rocks strike N. 10°W. to N. 60°E., and dip 5° to 36° SW. to NW.

Measurements were made of porosity, water content, grain density, and rock or bulk density of specimens of tuff from the U12b.03 and U12b.04 tunnels. These data were obtained to assist in the evaluation of the yield and determination of the effects of proposed nuclear detonations in the U12b.03 and U12b.04 shot chambers.

In contrast to the dry condition of the main U12b tunnel and tunnels U12b.01 and U12b.02, the U12b.03 and U12b.04 tunnels showed evidence of ground water. --M. Russell.

Contents:
Pt. 1. Introduction, by W. H. Diment and V. R. Wilmarth.
Pt. 2. Stratigraphy and Structure, by F. A. McKeown and D. D. Dickey.
Pt. 3. Petrology, by E. N. Hinrichs, T. Botinelly, and F. A. McKeown.
Pt. 4. Porosity, Water Content, and Density of the Tuff, by C. H. Roach, F. M. Byers, Jr., C. C. Hawley, and G. A. Izett.
Pt. 5. Ground Water, by Alfred Clebsch, Jr.

1-3190. Diment, W.H., and others. GEOLOGICAL SURVEY INVESTIGATIONS IN THE U12e.05 TUNNEL, NEVADA TEST SITE: U.S. Geol. Survey, Trace Elements Memo. Rept. 997, 70 p., 7 figs. incl. 3 maps (1 in pocket), cross sec., diag., 8 tables, Feb. 1959, 3 refs.

Preliminary results are given of the U. S. Geological Survey investigations in the U12e.05 tunnel at the U. S. Atomic Energy Commission's Nevada test site, Nye County, Nevada.

The U12e.05 tunnel, one of 2 laterals from the main U12e tunnel, trends W. and connects with the main tunnel about 1,960 ft. from the portal. The vertical and minimum cover over the original shot chamber are 1,150 and 950 ft., respectively.

The U12e tunnel extends beneath Rainier Mesa, a prominent topographic feature in the NW. part of the Nevada test site. The rocks exposed in the tunnel are part of the Oak Spring formation of Tertiary age and are predominantly tuff and tuffaceous sandstones. The Oak Spring formation is about 1,900 ft. thick and unconformably overlies limestone, dolomite, quartzite, and siliceous shale of late Paleozoic age. The contact between the Tertiary and Paleozoic rocks has an average strike of N. 30°E., dips NW. at a low angle, and is highly irregular. The Paleozoic rocks strike N. to N. 20°E., dip 10° to 70°W., or NW., and have been cut by NW.- to NE.-trending, steeply dipping, normal and reverse faults. NE. and ENE. folds with amplitudes of 50 to 100 ft. and N.- to NW.-trending faults with vertical displacements of as much as 50 ft. have been mapped in the Tertiary rocks. The tuffaceous rocks at the portal of the U12e tunnel strike N. 5° to 30°E. and dip 5° to 35°W. --M. Russell.

Contents:
Pt. 1. Introduction, by W. H. Diment and V. R. Wilmarth.
Pt. 2. Stratigraphy and Structure, by F. N. Houser and D. D. Dickey.
Pt. 3. Petrology, by E. N. Hinrichs, T. Botinelly, and R. E. Wilcox.
Pt. 4. Porosity, Density, and Water Content of Tuffs from U12e.05 Tunnel, by F. M. Byers, Jr.
Pt. 5. Nature of the Rock Surrounding the Final Shot Chamber for Blanca Event, by F. N. Houser.
Appendix A. Detailed Megascopic Descriptions of the Oak Spring Formation Exposed in the U12e.05 Tunnel, Rainier Mesa, Nye County, Nevada, by F. N. Houser and V. R. Wilmarth.

1-3191. Diment, W.H., and others. GEOLOGICAL SURVEY INVESTIGATIONS IN THE U12b.01 TUNNEL, NEVADA TEST SITE: U.S. Geol. Survey, Trace Elements Memo. Rept. 998, 38 p., 4 maps (2 in pocket), cross sec., diag., 7 tables, March 1959, ref.

The U12b.01 tunnel is part of the U12b (Rainier) tunnel system driven northwestward from the E. slope of Rainier Mesa. Geologic and geophysical studies in this tunnel were conducted by the U. S. Geological Survey on behalf of the Albuquerque Operations Office of the U. S. Atomic Energy Commission. This report includes a brief description of the stratigraphy and structure, and data on petrology, mineralogy, and chemical and physical properties of the rocks that are exposed in the tunnel.

The U12b.01 tunnel trends N. 10°W., and connects with the U12b tunnel at about 500 ft. from the portal. The U12b.01 tunnel is about 250 ft. long and contains an alcove 40 ft. long and 20 ft. wide, and a shot chamber 17 by 20 ft. The tunnel is irregular and ranges from 6 to 15 ft. in width and averages 7 ft. in height. Much of the tunnel has been supported using 6-ft. steel sets and wood planks for lagging. Vertical and minimum cover over the shot chamber at W. end of the tunnel are approximately the same, about 295 ft. --From introd.

Contents:
Pt. 1. Introduction, by W. H. Diment and V. R. Wilmarth.
Pt. 2. Stratigraphy and Structure, by F. A. McKeown and D. D. Dickey.
Pt. 3. Petrology, by T. Botinelly and E. N. Hinrichs.
Pt. 4. Porosity, Water Content, and Density, by C. H. Roach, F. M. Byers, Jr., G. A. Izett, and G. R. Johnson.

15. MISCELLANEOUS

1-3192. Alexandrov, Eugene A. VADEMECUM TO THE RUSSIAN GEOLOGICAL PERIODICALS: Econ. Geology, v. 54, no. 7, p. 1313-1314, Nov. 1959.

The subject matter of 14 Russian periodicals is listed in tabular form. Besides these, 112 geological journals, transactions, and bulletins were published in the Soviet Union in 1958. Some are abstracted in the United States by Geoscience Abstracts and by the Engineering Index. The Geochemical Society translates "Geokhimiya."--J. A. Chamberlain.

1-3193. Daniel, Glyn E. THE IDEA OF MAN'S ANTIQUITY: Sci. American, v. 201, no. 5, p. 167-176, 4 illus., Nov. 1959.

The "catastrophic" or diluvialist theory of geology of the 18th and early 19th centuries was perhaps most effectively refuted by the finding of human artifacts amid the remains of extinct animals. The archeological findings of Johann F. Esper, John Frere, William Buckland, Father MacEnery, Boucher de Perthes, and William Pengelly are reviewed and related to the effect they had on the biblical theory of man's origin, and the conflict in geology between the diluvialist and uniformitarianist theories.--M. Russell.

1-3194. Riley, Charles M. AN IRON FULGURITE FROM NEBRASKA: Nebraska, State Mus., Bull., v. 4, no. 5, p. 83-88, 2 illus., Sept. 1959, 10 refs.

From the time of the ancients man has been impressed with the force of lightning and its effect on the rocks at the surface of the earth. It was Saussure in 1786 who first wrote a scientific account of a true fulgurite, and a wealth of literature has been written about the subject since this time. Many unusual fulgurites have been described, some of which may not truly be the result of lightning. The Fe fulgurite is a strange conical object about 3 in. high composed mainly of tiny spheres and filaments of metallic Fe intermixed with a small amount of nonmetallic soil minerals. It is believed that a bolt of lightning hit an Fe object lying in a farmyard, instantly melted it, and somehow sprayed the molten Fe into the soil where it solidified. The power needed by a lightning bolt to instantly melt a mass of Fe this size was computed at 2050 x 10^6 watts.--Auth.

1-3195. PROFESSIONAL DIMENSIONS OF THE GEOSCIENCES: GeoTimes, v. 4, no. 4, p. 12-17, map, 7 graphs, 7 tables, Nov.-Dec. 1959.

Of approximately 24,000 geoscientists in the United States, 14,437, during the period 1956-1958, have returned Earth Science Register forms, a phase of the National Science Foundation's National Register of Scientific and Technical Personnel. From these returns, statistical tables and graphs are presented on the following aspects of the profession: ratio of geologists to geophysicists, geographic distribution, type of employer, employment function, scientific specialties, extent of education, and salary data by age, education, and type of employer.--M. Russell.

1-3196. Dons, J.A. GEOLOGY IN NORWAY: GeoTimes, v. 4, no. 4, p. 8-9, 36-37, 3 illus., Nov.-Dec. 1959.

The major geological institutions of Norway are listed; they include Norsk Geologisk Forening (Geological Society), Norges Geologiske Undersøkelse (Geological Survey), the Institutt for Geologi, and the Geologisk Museum, the latter 2 at the University of Oslo. Norway's plans for participation in the forthcoming XXI International Geological Congress include many field trips and the functioning of an 18-member Congress committee appointed by the government. Norway publishes 2 major geologic journals and 6 others of mixed content. Studies in granitization and metamorphic and metasomatic processes are significant Norwegian contributions. Outstanding features of Norwegian geology include Caledonian mountain building, Permian volcanism, and Pleistocene glaciation.--M. Russell.

1-3197. Roedder, Edwin. TIME FOR SCIENCE: GeoTimes, v. 4, no. 4, p. 24-25, 51, 3 illus., Nov.-Dec. 1959.

In Washington, D.C., approximately 45,000 school children in the 5th and 6th grades are shown "Time for Science," a half-hour educational TV program presented by the Greater Washington Educational Television Association. The 2-year cycle of 150 programs includes many of primary geologic concentration.--M. Russell.

1-3198. Hill, Mason L. SCHOOL SCIENCE TEACHING: GeoTimes, v. 4, no. 4, p. 10, Nov.-Dec. 1959.

Geologists should be recruited to teach general science in high school. Such a program would help fill a critical need for an expanded science program in schools and at the same time help ease the current unemployment problem among geologists.--M. Russell.

1-3199. Fan, Paul H. DEVELOPING A BETTER GEOLOGICAL PROFESSION: GeoTimes, v. 4, no. 4, p. 26-27, Nov.-Dec. 1959.

There are at present not enough jobs available for all the geologists who are being graduated each year. To improve the economic position of geologists and to better their professional caliber, students of geology should concentrate on biology, chemistry, or physics in their undergraduate course and not enter professional training until reaching the graduate level. The scope of the profession should be broadened to include geochemistry and geophysics.--M. Russell.

1-3200. Lange, Erwin F. DR. JOHN EVANS, U.S. GEOLOGIST TO THE OREGON AND WASHINGTON TERRITORIES: Am. Philos. Soc., Proc., v. 103, no. 3, p. 476-484, 3 illus., June 1959, 3 refs.

A short biographical sketch of Dr. John Evans, 1812-1861, is given, with a few short exerpts from his reports. Dr. Evans worked for the U. S. Geological Survey. In 1849 he described fossils from the Cretaceous and Tertiary bad lands W. of the Missouri River; in 1851 he was appointed to make a survey along proposed rail lines in Oregon. His most extensive report on geological explorations in Oregon was never published.--M. Russell.

1-3201. Cate, Addison S. J.PETER LESLEY, A BIOGRAPHICAL SKETCH: GeoTimes, v. 4, no. 4, p. 18-19, 45, Nov.-Dec. 1959.

The geological career of J. Peter Lesley is reviewed, from his earliest experience as an assistant on the Pennsylvania Geological Survey in the Anthracite Region in 1838, through his training in theology and geology at Princeton and in Europe, to his final work as director of the Second Geological Survey of Pennsylvania from 1874-1893. He died in 1904. --M. Russell.

1-3202. EMPLOYMENT OUTLOOK: GeoTimes, v. 4, no. 4, p. 20-21, 2 tables, Nov.-Dec. 1959.

During Sept. 1959, the American Geological Institute conducted a survey of employment among geologists and geophysicists. Less than 5% of the geoscientists are unemployed; the nationwide figure for the profession is probably about 2.6% unemployed. --M. Russell.

AUTHOR INDEX

Abstract

Abelson, Philip H. 1-3057, 1-3062
Acheson, C. Harold. 1-3036
Addicott, Warren O. 1-2983
Aho, Aaro E. 1-2946
Alekseev, A.S. 1-3046
Alexandrov, Eugene A. 1-3192
Allais, G. 1-3093
Alverson, Douglas C. 1-2977
Anderson, Alfred L. 1-2947
Anderson, Charles A. 1-2934
Andrews, A.B. 1-3037
Armstrong, J.E. 1-2941, 1-3110
Arrhenius, Gustaf O.S. 1-3058
Ashworth, Edwin T. 1-2994
Atchison, Thomas C. 1-3182
Atwater, Gordon I. 1-2963
Ault, Wayne U. 1-3069
Azad, J. 1-3164

Babich, V.M. 1-3046
Baptist, Oren C. 1-3159
Barnes, Farrell F. 1-3167
Barton, Paul B., Jr. 1-3071
Beckmann, Walter C. 1-3015
Bekturov, A. 1-3147
Bell, W.A. 1-2970
Berry, James E. 1-3156
Berzon, I.S. 1-3049
Bierschenk, W.H. 1-3139
Boltovskoy, Esteban. 1-2993
Bond, Fred C. 1-3174
Boyd, Francis R. 1-3075
Boyd, Josephine W. 1-3133
Boyd, William L. 1-3133
Bramkamp, R.A. 1-2938
Bretz, J. Harlen. 1-2955
Bronlund, E. 1-2944
Brothers, R.N. 1-2965
Brunk, Ivan W. 1-3131
Bryson, Reid A. 1-2957
Büdel, Julius. 1-2953
Burbank, W.S. 1-2935
Burnside, R.J. 1-2974
Butkovich, T.R. 1-3188

Cadilla, José F. 1-3148
Cameron, Jack. 1-3024
Caputo, Michele. 1-3001
Carder, Dean S. 1-3032
Carr, Wilfred J. 1-2977
Cass, J.T. 1-2933
Castle, R.O. 1-2936
Cate, Addison S. 1-3201
Chayes, Felix. 1-3074
Choquette, A.L. 1-2962
Chow, Tsaihwa J. 1-3094
Clark, Sydney P., Jr. 1-3080
Clausing, D.P. 1-3183
Cloud, W.K. 1-3032
Coates, D.F. 1-3179
Cobb, Edward H. 1-3167
Conklin, Dora R. 1-3141
Coombs, D.S. 1-3084
Creath, Wilgus B. 1-2998
Crook, Keith A.W. 1-3115
Crowell, John C. 1-2961
Cupps, C.Q. 1-3161
Curien, H. 1-3093

Dana, James D. 1-3096
Daniel, Glyn E. 1-3193
Darer, R.S. 1-3147
Davidson, C.F. 1-3144
Davis, Gordon L. 1-3067
Dean, R.G. 1-3117
De Bremaecker, J. Cl. 1-3030
Degens, Egon T. 1-3060
Dergunov, I.D. 1-3055
de Vries, Hessel. 1-3066
de Waard, D. 1-3109
Diment, W.H. 1-3189, 1-3190, 1-3191

Abstract

Dingle, W.B. 1-3150
Djingheuzian, L. E. 1-3172
Dons, J. A. 1-3196
Drooger, C. W. 1-2995
Duvall, Wilbur I. 1-3182

Eagleson, P. S. 1-3117
Eargle, D. Hoye 1-2976
Echols, Dorothy Jung 1-2998
Eckel, Edwin B. 1-2935
Eckelmann, F. Donald 1-2979
Ehmann, W. D. 1-3089
Elliott, D. H. 1-2960
Ellis, A. J. 1-3084
Emerson, William K. 1-2982, 1-2983, 1-2984
Enenshtein, B. S. 1-3014
Epstein, Sanuel 1-3068
Eugster, Hans P. 1-3064, 1-3076

Fan, Paul H. 1-3199
Fedoseenko, N. E. 1-3017
Finkel, Herman J. 1-2958
Fogelson, David E. 1-3182
Ford, Ronald E. 1-3140
Forman, McLain J. 1-2963
Fortson, Charles W. 1-3142
Fowles, G. R. 1-3181
Frolov, A. D. 1-3012
Fry, J. 1-3161
Fyfe, W. S. 1-3084
Fyles, John G. 1-2999

Gangi, Anthony F. 1-3045
Garrels, Robert M. 1-3059
Gehman, Harry Merrill, Jr. 1-3112
Ghose, Subrata 1-3098
Gilbert, Ray E. 1-3013
Gill, Harold E. 1-3135
Goddard, Edwin N. 1-2935
Goldberg, Edward D. 1-3085
Goldsmith, Julian R. 1-3073
Graham, John A. 1-3153
Grannemann, W. W. 1-3016
Green, Jack 1-2964
Grine, Donald R. 1-3181
Gruner, John W. 1-3102
Gryc, George 1-3158
Gutenberg, B. 1-3020

Hall, Donald H. 1-3007
Hall, H. Tracy 1-3000
Hamaguchi, H. 1-3090
Hamilton, Edwin L. 1-3120
Hanson, William E. 1-3063
Hantush, Mahdi S. 1-3126
Hardy, H. R., Jr. 1-3177
Hargraves, Robert B. 1-3008
Harker, R. Ian 1-3081
Harris, H. D. 1-2968
Harrison, J. C. 1-3003
Harrison, Melvin A. 1-3187
Haskew, Henry C. 1-3127
Hawkes, H. E. 1-3061
Haysaka, Ichirō 1-2990
Heezen, Bruce C. 1-3116, 1-3118
Hellner, Erwin 1-3098
Henderson, G. G. L. 1-2942
Henry, Harold R. 1-3129
Hertlein, Leo G. 1-2984
Higgins, Gary H. 1-3052, 1-3130
Hill, Mason L. 1-3198
Hill, Patrick Arthur 1-2952
Hiltermann, Heinrich 1-2991
Hoffman, J. H. 1-3088
Holland, Stuart S. 1-2940
Holt, C. L. R., Jr. 1-3138
Horton, C. W. 1-3043
Howell, B. F., Jr. 1-3037
Huber, R. E. 1-3037
Huffman, George G. 1-2971
Huizenga, John R. 1-3089

Abstract

Hurlbut, Cornelius S., Jr. 1-3096

Ichikuni, M. 1-3092
Illinois, Division of Industrial Planning and Development 1-3152
Isaev, V. S. 1-3035

Jacobsen, Lynn 1-3157
Jeffreys, Harold 1-3185
Johansson, C. H. 1-3184
Johnson, Gerald W. 1-3052, 1-3186
Junner, N. R. 1-3145

Kalashnikov, A. G. 1-3009
Kamb, W. Barclay 1-2954
Kanakoff, George P. 1-2982
Kansas Geological Society 1-3160
Karus, E. V. 1-3040
Keith, Mackenzie L. 1-3060
Keller, Harry B. 1-3187
Kennedy, George C. 1-3082
Kern, B. F. 1-3143
Khmelevskoi, V. K. 1-3012
Knopoff, Leon 1-3045
Kohout, F. A. 1-3134
Kolosenko, M. N. 1-3019
Korzhinsky, D. S. 1-3108
Kovalev, O. I. 1-3038
Krauskopf, Konrad B. 1-3070
Krumbach, A. W., Jr. 1-2959
Kuellmer, Frederick J. 1-3097
Kullerud, Gunnar 1-3072
Kulp, J. Laurence 1-2979
Kuroda, R. 1-3090
Kuzivanov, V. A. 1-3004

Lagaaij, R. 1-2997
Landes, Kenneth K. 1-3155
Lange, Erwin F. 1-3200
Langefors, Ulf 1-3180
Lathbury, Alison 1-2957
Leech, G. B. 1-2943
Lemcoe, M. M. 1-3168
Leopold, Luna B. 1-3124
Leskevich, I. E. 1-3101
Libby, W. F. 1-3065
Lindström, Maurits 1-2996
Long, Leon E. 1-2979
Lovering, T. S. 1-2935
Luedke, Elaine M. 1-3153
Luginets, I. P. 1-3163
Lundberg, Hans T. 1-2945
Luskin, Bernard 1-3015
Lyuber, A. A. 1-3166

MacClintock, Paul 1-3113
MacDonald, Gordon J. F. 1-3054, 1-3079
McKenna, Malcolm C. 1-2987
McLaughlin, R.J.W. 1-3091
Machamer, Jerome F. 1-3146
Madden, Theodore R. M. 1-3010
Malovichko, A. K. 1-3006
Marshall, Donald J. 1-3010
Matsuoka, M. 1-3083
Maxwell, Arthur E. 1-3056
Maxwell, John C. 1-2978
Mayeda, Toshiko 1-3087
Melamud, A. Ya. 1-3034
Mellis, Otto 1-3119
Meyer, F. W. 1-3134
Miller, Don J. 1-3158
Miller, Lynn M. 1-3125
Milton, Charles 1-3064
Mokeeva, V. I. 1-3100
Mook, Charles C. 1-2985
Muller, Leopold 1-3176
Mun, A. I. 1-3147

Nakkady, S. E. 1-2992
Navarre, Alfred T. 1-3142

Abstract

Nelson, Arthur E. 1-2937
Nier, Alfred O. 1-3088
Norris, D. K. 1-2975
Norris, Stanley E. 1-3137
Northrop, Stuart A. 1-3104
Nygreen, Paul W. 1-2972

Odintsov, M. M. 1-3149
Olenin, V. B. 1-3162
Osborn, E. F. 1-3106
Owen, Edgar W. 1-3154

Parkhomenko, I. S. 1-3038, 1-3047
Pasechnik, I. P. 1-3017
Patterson, Claire C. 1-3094
Payne, Thomas G. 1-3158
Peselnick, Louis 1-3041
Péwé, Troy L. 1-2956
Picard, M. Dane 1-2973
Pickett, A. G. 1-3168
Piret, Edgar L. 1-3171
Popov, E. I. 1-3002
Popov, I. I. 1-3018
Postel, A. Williams 1-2937
Puchkov, S. V. 1-3023

Ramirez, Leon F. 1-2938
Raup, David M. 1-2981
Reed, George W. 1-3078
Reid, Rolland R. 1-2948
Rezanov, I. A. 1-3027
Richards, T. C. 1-3039
Rigby, J. Keith 1-2949
Riley, Charles M. 1-3194
Rinehart, John S. 1-3173
Ritzma, Howard R. 1-2950
Riznichenko, Yu. V. 1-3021
Roberts, Archie C. 1-3015
Robinson, L. H., Jr. 1-3178
Roddick, J. A. 1-3110
Roedder, Edwin 1-3197
Romanuk, V. A. 1-3005
Romney, Carl 1-3033
Rose, Harold J. 1-3165
Rumanova, I. M. 1-3099
Rybakova, E. V. 1-3014

Savarensky, E. F. 1-3031
Scheidegger, Adrian E. 1-3025
Shamina, O. G. 1-3044
Silaeva, O. I. 1-3044
Simpson, George Gaylord 1-2986, 1-2987, 1-2988, 1-2989
Skipetrova, T. I. 1-3099
Skropyshev, A. V. 1-3095
Socin, C. 1-2995
Soister, Paul E. 1-3141
Sokolov, B. A. 1-3162
Solovev, S. L. 1-3028
Stakhovskaya, Z. I. 1-3042
Stonehouse, D. H. 1-3151
Stringer, K. V. 1-3164
Sudo, Toshio 1-3083
Sutton, George H. 1-2967

Tainsh, H. R. 1-3164
Talsma, T. 1-3127
Talwani, Manik 1-2967
Tamrazyan, G. P. 1-3029
Tatevosyan, L. K. 1-2969
Taylor, A. M. 1-3084
Terasmae, Jaan 1-2999
Thompson, James B., Jr. 1-3077
Tilton, G.R. 1-3067
Tocher, Don 1-3024
Treitel, Sven 1-3041
Treskov, A.A. 1-3022
Trokhova, A.A. 1-3162
Turekian, K.K. 1-3086
Tuttle, O. Frank 1-3107

Abstract

Twidale, M.A. 1-3172

Upson, Joseph E. 1-3136
Urey, H.C. 1-3087

Van Bavel, Cornelius H.M. 1-3132
Vassilyev, Yu. I. 1-3038
Vassoevich, N.B. 1-3114
Violet, Charles E. 1-3052
Volarovich, M.P. 1-3042
Von Herzen, R. 1-3056

Ward, Richard F. 1-3111
Ward, Stanley H. 1-3011
Wasserburg, G.J. 1-2980
Watson, K.K. 1-3128
Wetherill, G.W. 1-2980
Weyl, Peter K. 1-3121
Whitney, Bruce B. 1-3174
Wiesnet, D.R. 1-2937

Abstract

Wilkerson, Albert S. 1-3103
Williams, J. Stewart 1-2951
Wilson, Stanley D. 1-3175
Wiseman, John D.H. 1-3123
Woodland, Mary Vogt 1-3105
Woollard, G.P. 1-2966
Worzel, J. Lamar 1-2967
Wright, Lauren A. 1-2980
Wrucke, Chester T. 1-3153
Wuerker, Rudolph G. 1-3170
Wyllie, P.J. 1-3107

Yakovlev, A.F. 1-3050, 1-3051

Zaffarano, R.F. 1-3161
Zeleny, Richard A. 1-3171
Zen, E-An 1-3122
Zharkov, V.N. 1-3053
Zietz, Isidore 1-3041
Zvolinsky, N.V. 1-3048